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CONTROL OF DOMESTIC RATS AND MICE. TRAINING GUIDE. RODENT CONTROL SERIES

Bayard F. Bjornson, et al

Environmental Control Administration
Rockville, Maryland

1970

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CONTROL OF DOMESTIC RATS & MICE

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service

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Control of Domestic Rats & Mice

TRAINING GUIDE --- RODENT CONTROL SERIES

Bayard F. Bjornson, Harry D. Pratt, and Kent S. Littig

Details of illustrations in
this document may be better
studied on microfiche.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration
Rockville, Maryland 20852

I

Controlling rat populations, not individual rats, is the key to a successful rodent- control program in a community.

Note: The use of trade names and the names of supply or manufacturing firms is for identification purposes only and does not constitute endorsement by the Public Health Service.

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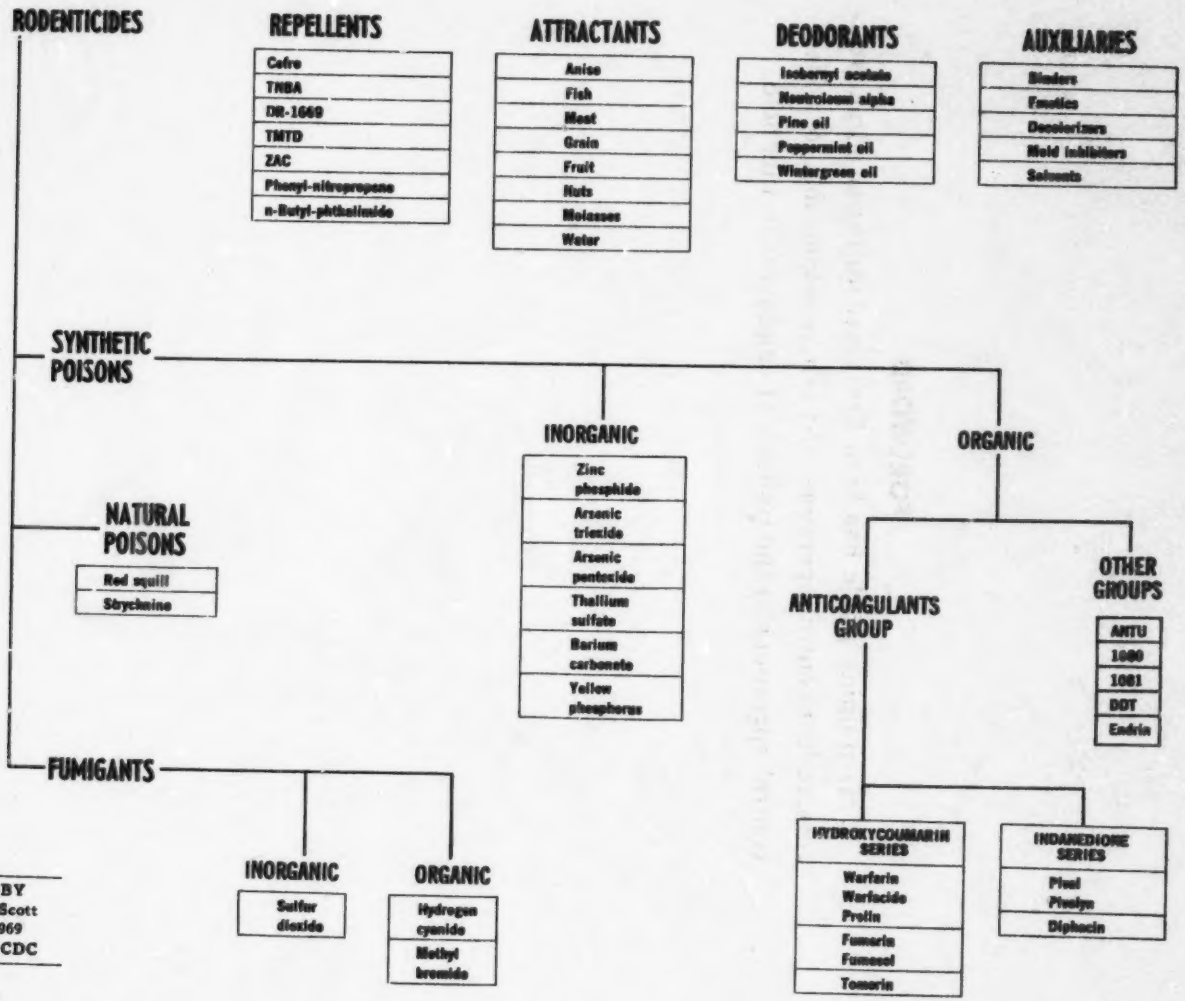
II

FOREWORD

This training guide has been developed to assist administrators, rodent-control operators, and others responsible for rodent-control operations in the training of employees in this field.

THE CHEMICAL CONTROL OF RODENTS



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Control of Domestic Rats & Mice

RODENTS AND HUMAN WELFARE

Rats and mice have accompanied man to most of the areas of the world he has settled. Historically they have been responsible for more human illness and deaths than any other group of mammals. They are universally feared and despised, yet man's indifference and carelessness in handling food and refuse have fostered populations of them in such close proximity to his home and work that they are commonly referred to as "domestic" rodents.

ECONOMIC IMPORTANCE

Rats in the human environment cause enormous economic losses. They consume or contaminate vast quantities of food and feed, and they destroy other property, as when they cause fires by gnawing the insulation from electric wires. Many fires of unknown origin must be attributed to rats.

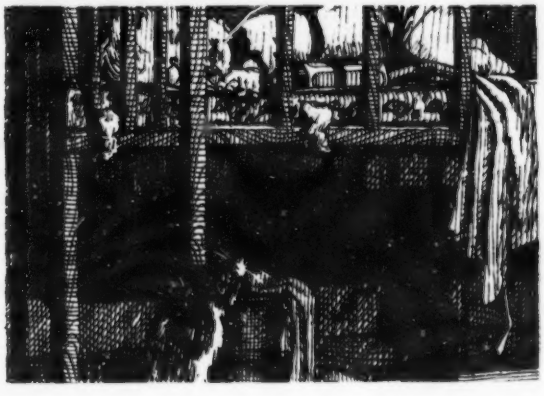
No reliable estimate of the rat population of the United States is available as a basis for calculating these losses, although the figure of one rat for every person has frequently been quoted in the literature. If, in consideration of recent improvements in environmental sanitation and rodent control, this rough estimate used in the past is reduced by one-half, that is, to an estimated one rat for each two people, then the United States has some 100,000,000 rats. Each rat damages between $1 and $10 worth of food and other materials per year by gnawing and feeding, and contaminates 5 to 10 times more. Thus, rats may cost the United States between $500,000,000 and $1,000,000,000 annually in terms of direct economic losses.

RAT BITES

In addition to the annual dollar losses due to rats, there is also the intangible cost of rat-associated injury and illness. Rat bites create a serious health problem and are far more common than most people realize. In some of the larger cities, hundreds of rat bites are reported each year, and certainly there are many cases that are never reported.

Based upon available records, large metropolitan areas of the United States experience rat bite at the rate of approximately 10 per 100,000 persons per year. This amounts to three to four thousand cases annually just in the large cities alone, and the cases unreported from them and from the smaller cities and towns undoubtedly total several thousand more.

Helpless infants and defenseless adults (invalids and unconscious persons) are particularly subject to attack by rats, and occasionally a rat-bite wound causes death. The victim of an attack is usually terrified by the experience, and the mental and emotional scars that remain are often deeper than the physical scars. Rat-bite wounds should be promptly and carefully disinfected to prevent secondary infection, and where necessary the victim should then be referred to a doctor.



RODENT-BORNE DISEASES

Rats and mice are responsible for spread of a number of diseases, either directly, as by contamination of human food with their urine or feces, or indirectly, by way of rodent fleas and mites. Following are brief descriptions of the more common of these diseases.

RAT-BITE FEVER

Causative agent, *Streptobacillus moniliformis*

The bacteria that cause rat-bite fevers are found on the teeth and gums of many rats and are transferred from rat to man by the bite of the rat. The most frequently occurring rat-bite fever in the United States is called Haverhill fever. It is similar to rat-bite fever of the Orient called sodoku (caused by *Spirillum minus*).

LEPTOSPIROSIS

(Weil's Disease)—Causative agent, *Leptospira* spp., primarily *L. icterohemorrhagiae*

Leptospirosis is a mild to severe infection that is seldom fatal. Human cases of the disease result from direct or indirect contact with infected urine of rodents and of certain other animals. The spirochetes, which are found in water or on food, may enter through mucous membranes or minute cuts or abrasions of the skin. Thus, Weil's disease is often found in sailors, miners, sewer workers, fish or poultry dealers, and abbatoir workers. In a recent study in Hawaii, Norway rats, roof rats, and house mice were found to have high *L. icterohemorrhagiae* carrier rates.

SALMONELLOSIS

Causative agent, *Salmonella* spp.

Salmonellosis, which is generally classed as food poisoning, is a common disease of worldwide distribution. It is an acute gastroenteritis produced by members of the *Salmonella* group of bacteria pathogenic to man and other animals. They are spread in various ways, one being through food contaminated with rat or mouse feces containing *Salmonella* organisms.

TRICHINOSIS

Causative agent, *Trichinella spiralis*

Trichinosis results from an infection of the intestines and muscles by larvae and cysts of *Trichinella spiralis*. Man, hogs, and rodents may develop the disease from eating infected pork that is raw or insufficiently cooked. In addition, research has shown that hogs experimentally fed trichina-infected feces of rats and mice readily become infected. This indicates that rodents may play an important role in spreading trichinosis to hogs fed on garbage containing infected rat feces. Such interchange of organisms may significantly help to maintain the rodent-swine-man cycle of this disease.

MURINE TYPHUS FEVER

Causative agent, *Rickettsia typhi*

Murine typhus fever is distributed throughout the Southeastern and Gulf Coast States and southern California. Rats are the reservoir animals from which the disease reaches man by way of rat fleas. The oriental rat flea, *Xenopsylla cheopis*, is considered the most important vector of the disease. The causative organism enters the bloodstream when feces of infected fleas are scratched or rubbed into a flea-bite wound or other break in the skin. Murine typhus is similar to epidemic or louse-borne typhus, but illness is much milder and the fatality rate in untreated cases is much lower.

PLAGUE

Causative agent, *Pasteurella pestis*

Plague is the "Black Death" that once killed millions of people in Europe, Asia, and Africa. No serious outbreaks of plague have occurred in the United States since 1924. However, a reservoir of the disease exists in wild rodents of the western states, where the bacteria are transmitted from one rodent to another and sometimes to man by the bite of rodent fleas. There is always the danger that domestic rodents will become infected, and that they, in turn, will carry the infection to human population centers. The disease is generally fatal to the rat and the flea, and the death rate in untreated human cases is extremely high.

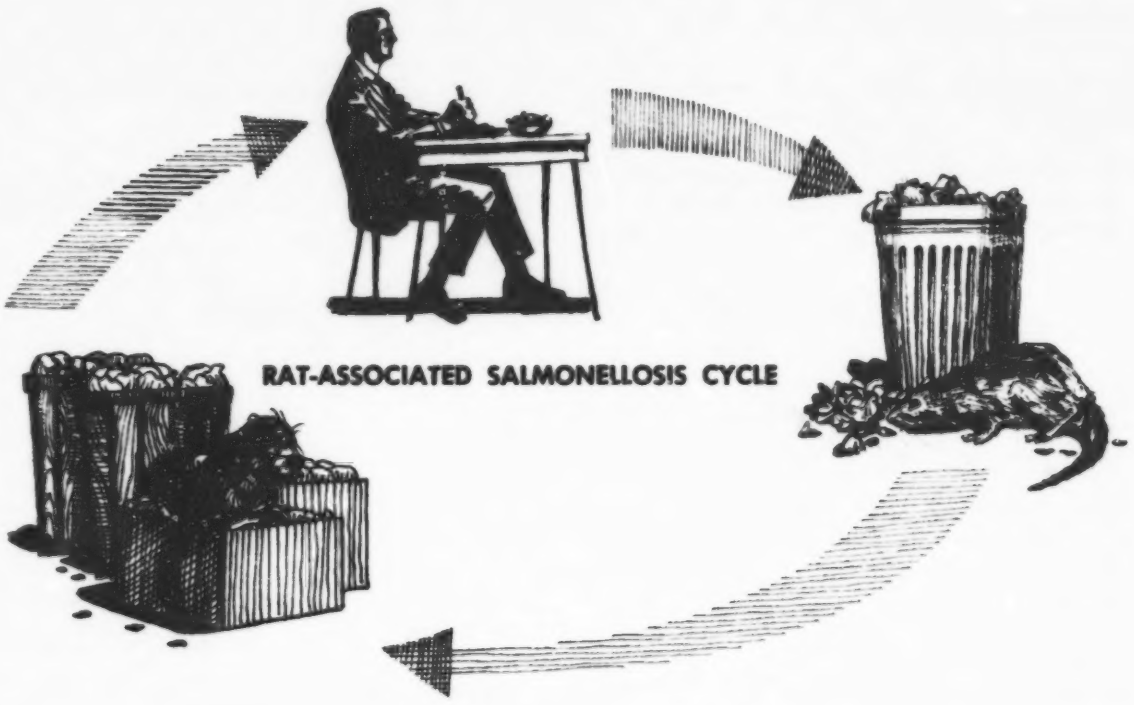
RICKETTSIALPOX

Causative agent, *Rickettsia akari*

Rickettsialpox is a mild nonfatal disease resembling chickenpox. It is transmitted from the house mouse to man by the bite of the house-mouse mite, *Liponyssoides sanguineus*. In this country rickettsialpox has been reported from Boston, Mass., West Hartford, Conn., New York, N.Y., Cleveland, Ohio, and Philadelphia, Pa.

OTHER DISEASES

A number of other diseases of less frequent occurrence are associated with domestic rodents. Among them are toxoplasmosis, listeriosis, and lymphocytic choriomeningitis.



DESCRIPTION AND HABITS OF DOMESTIC RATS AND MICE

The term "domestic rodents" includes Norway rats, roof rats, and house mice—members of the order Rodentia, family Muridae. These rodents are best characterized by having a single pair of incisor teeth on each jaw and by the absence of canine teeth.

BIOLOGICAL FACTORS

NORWAY RAT

The Norway rat *(Rattus norvegicus)*, predominantly a burrowing rodent, is the most common and the largest of the domestic rats. It is distributed generally throughout the temperate regions of the world, including the United States. Common names for the species are the brown rat, the house rat, the barn rat, the sewer rat and the wharf rat.

Adult weight: 16 or more ounces; adults average about a pound.

Fur: Coarse, generally reddish brown to grayish brown, with many variations.

Body: Heavy-set, and with muzzle blunt.

Tail: Bicolored, shorter than body and head combined.

Ears: Small, close-set.

Droppings: Large (½- to ¾-inch long), capsule-shaped (see figure, page 7).

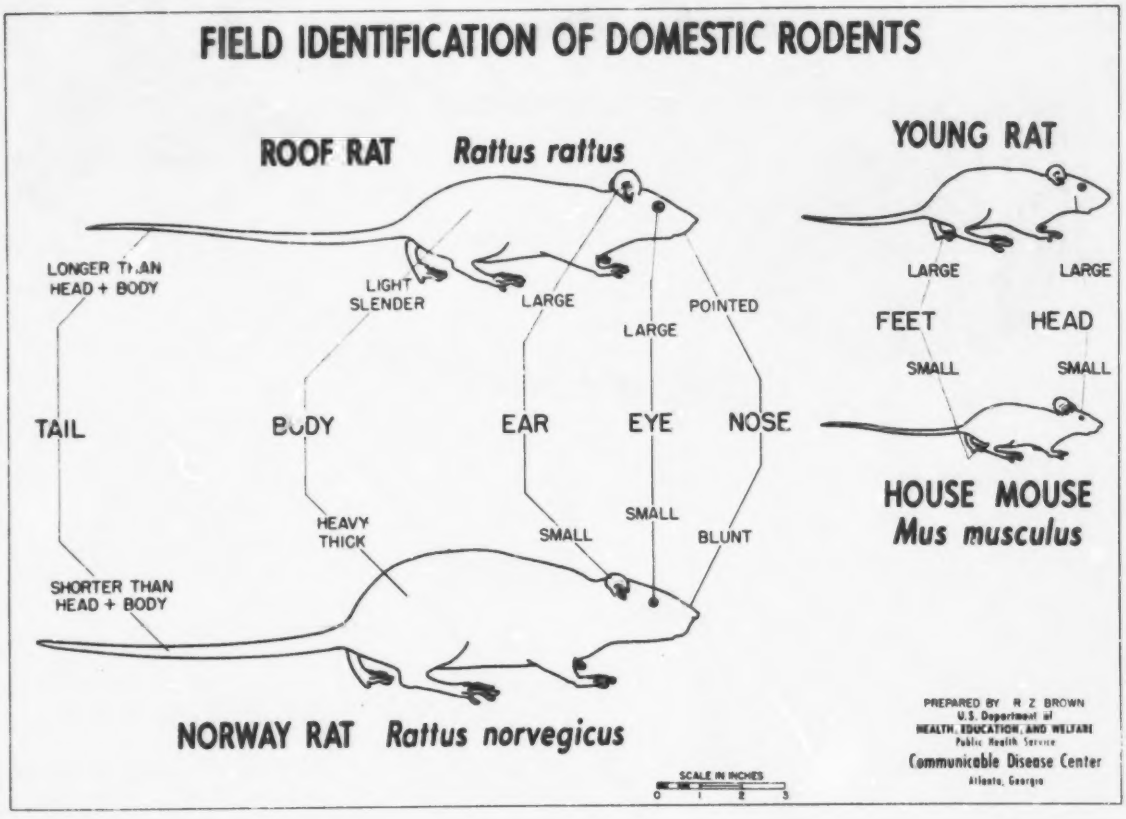
Sexual maturity: Attained in 2 to 3 months.

Gestation period: Averages 22 days.

Young: Average 8 to 12 per litter.

Number of litters: Averages 4 to 7 per year.

Number weaned: Averages about 20 young per year per female.



Length of life: Averages about 1 year.
Harborage: Outdoors—in burrows in the ground and under foundations of buildings, and in rubbish dumps; indoors—between floors and walls, in enclosed spaces of cabinets, shelving, and appliances, in piles of rubbish, and in any other space concealed from view.
Range: Frequently 100-150 feet.
Food and water: Omnivorous; garbage, meat, fish and cereal baits are well accepted; daily requirement is ¾ to 1 ounce of dry food, ½ to 1 ounce of water.

ROOF RAT

The roof rat *(Rattus rattus)* is somewhat smaller than the Norway rat and is a more agile climber. In the United States its range is confined largely to the South and to the Pacific coast and Hawaii. Worldwide, it is found most abundantly in the tropical or temperate regions but is rare or absent in the colder portions of the world.
Adult weight: 8 to 12 ounces.
Fur: Three color phases in the United States: the black rat *(Rattus rattus rattus)*, black to slate-gray colored; the Alexandrine rat *(Rattus rattus alexandrinus)*, tawny above and grayish-white below; the fruit rat *(Rattus rattus frugivorus)*, also tawny above, with white to lemon colored belly. All three subspecies have long prominent guard hairs, and they interbreed.
Body: Slender, muzzle pointed.
Tail: Single color, longer than body and head combined.
Ears: Large, prominent.
Droppings: Medium-sized (⅓- to ½-inch long), spindle-shaped (see figure, page 7).
Sexual maturity: Attained in 2 to 3 months.
Gestation period: Averages 22 days.
Young: Average 6 to 8 per litter.
Number of litters: Averages 4 to 6 per year.
Number weaned: Averages about 20 young per female.
Length of life: Averages about 1 year.
Harborage: Above ground level; indoors—in attics, between walls, and in enclosed spaces of cabinets and shelving; outdoors—in trees and dense vine growth, and in some California cities, in sewers.
Range: Frequently 100-150 feet.
Food and water: Omnivorous; vegetables, fruits and cereal grains preferred; daily requirement is ½ to 1 ounce of dry food and up to 1 ounce of water.

HOUSE MOUSE

The house mouse *(Mus musculus)*, the smallest of the domestic rodents, is widespread and abundant throughout the United States. It is found throughout the world from the tropics to the Arctic regions.
Adult weight: ½ to ¾ ounce.
Fur: Dusky-gray.
Body: Small, slender.
Tail: Semi-naked, about as long as body and head combined.
Ears: Moderately large, prominent.
Droppings: Small ($\frac{3}{16}$- to ¼-inch long), rod-shaped (see figure, page 7).
Sexual maturity: Attained in 1½ months.
Gestation period: Averages 19 days.
Young: Average 5 to 6 per litter.
Number of litters: As many as 8 per year.
Number weaned: Averages 30-35 young per year per female.
Length of life: About 1 year.
Harborage: Nest in any convenient space in walls, cabinets, furniture or stored goods.
Range: Frequently 10 to 30 feet.
Food and water: Omnivorous; cereal grains preferred; the mouse is a nibbler; daily requirement is $\frac{1}{10}$-ounce of dry food, requires little water ($\frac{3}{100}$ of an ounce per day), often obtained in the foods it eats.

SENSES, AGILITY, AND REACTIONS OF RODENTS

Touch—Well developed in highly sensitive whiskers or *vibrissae*, and certain guard (tactile) hairs. Rats and mice prefer to run along walls or between things where they can keep their whiskers in contact with side surfaces.
Vision—Not too well developed. Apparently they are color blind, so any distinctive coloring of poison baits does not reduce their acceptance to rats.
Smell—Keen. Rodents apparently like the odors of most foods eaten by man. They are accustomed to the smell of man, so his odor on baits and traps does not repel them.

Taste—Not as sensitive as in man. Rats associate sickness caused by poison bait with the bait and not the poison. They prefer fresh food to decayed food.

Hearing—A keen sense of hearing. They can locate the source of a noise within 6 inches. Unusual noises cause rodents to attempt escape.

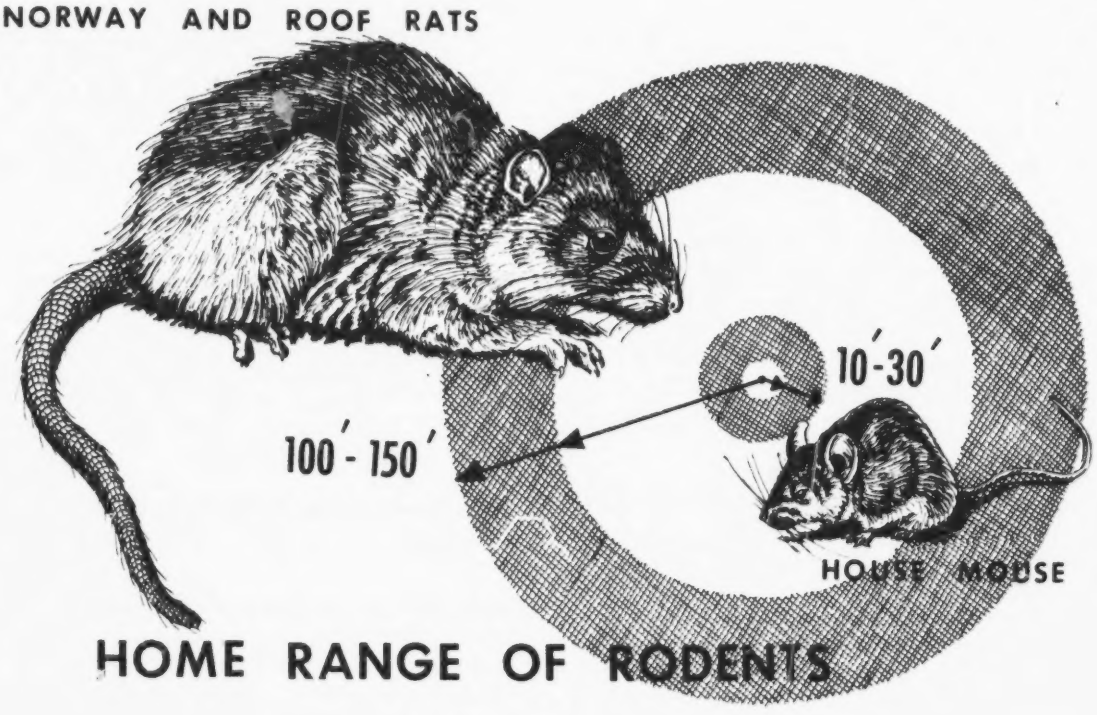
Balance—Excellent. A falling rodent always lands on its feet. The roof rat even maintains its balance well while walking on suspended wires.

Reaction to Strange Objects—Rats may avoid a new sound or a strange object in their environment for three or more days, particularly if their associates are alarmed by it. Other objects are readily accepted by them (examples: food, garbage). As rodent population pressures build, the rats frequently exhibit "chain-fright reaction" to disturbances. Mice are more likely to explore new objects, and to be caught in newly set traps.

Climbing—Roof rats and house mice are good climbers, and the Norway rat can climb quite well when necessary (see under Ratproofing, page 33).

Jumping and Reaching—Rats can jump nearly 2 feet vertically, 3 feet with a running start; they can jump 4 feet horizontally, and 8 feet from an elevation that is 15 feet above the finish point. Rats can reach upward about 18 inches.

Swimming—Rodents are good swimmers. They are able to swim up through floor drains and toilet-bowl traps.



RECOGNIZING RAT AND MOUSE SIGNS

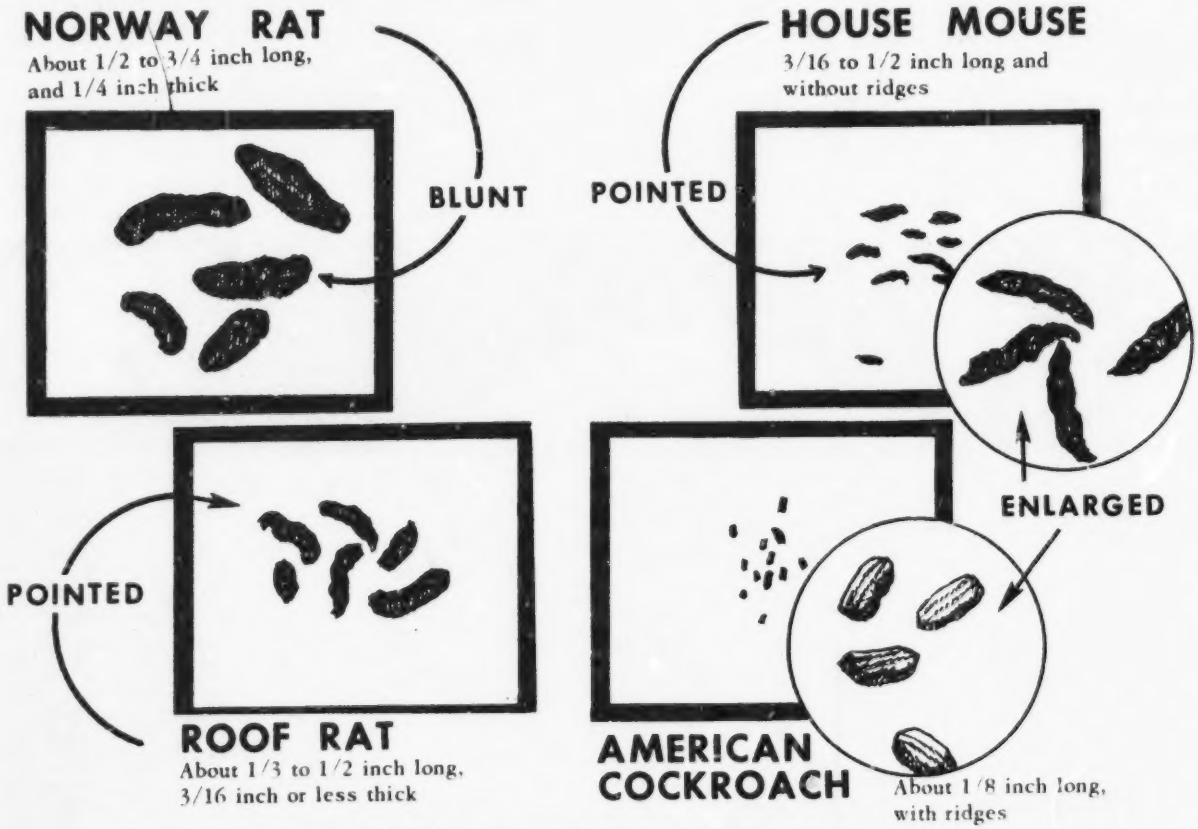
Rats and mice are habitually nocturnal and secretive and are rarely seen during the day except when infestations are heavy. Therefore, it is necessary to interpret signs of their activities properly in order to plan control work. These signs are found in secluded places, such as along walls, under piles of rubbish, and behind or under boxes, boards, and thick vegetation. From the rodent signs, one can tell the species present, and whether a rodent infestation is current or old, heavy or light.

DROPPINGS

Fresh droppings of feces are usually moist, soft, shiny, and dark, but in a few days they become dry and hard. Old droppings are dull and grayish and crumble when pressed with a stick.

RUNWAYS

Rats habitually use the same runways between food, water, and harborage. Because of the keenly developed sense of touch in their vibrissae (whiskers) and in specialized hairs along the body, rats prefer continual body contact with at least one vertical surface, such as a fence or wall. Rats also follow "odor trails." Outdoors, their runways are narrow pathways of beaten earth swept clear of debris. Indoors, greasy runways are found along walls, steps, and rafters. Undisturbed cobwebs and dust in a runway indicate that it is not in use.



RUBMARKS

Along regularly traveled runways, a dark, greasy mark forms from contact by the rodent's body. Fresh marks are soft and will smear if rubbed. As the grease ages, it dries and gathers dust and will flake off when scratched with a fingernail. The rubmarks of the Norway rat are most commonly found along runways near ground or floor level, while those made by the roof rat are most commonly seen overhead as swing marks beneath beams or rafters at the point where they connect to the walls. Mice do not leave detectable rubmarks except when the infestation is heavy.

BURROWS

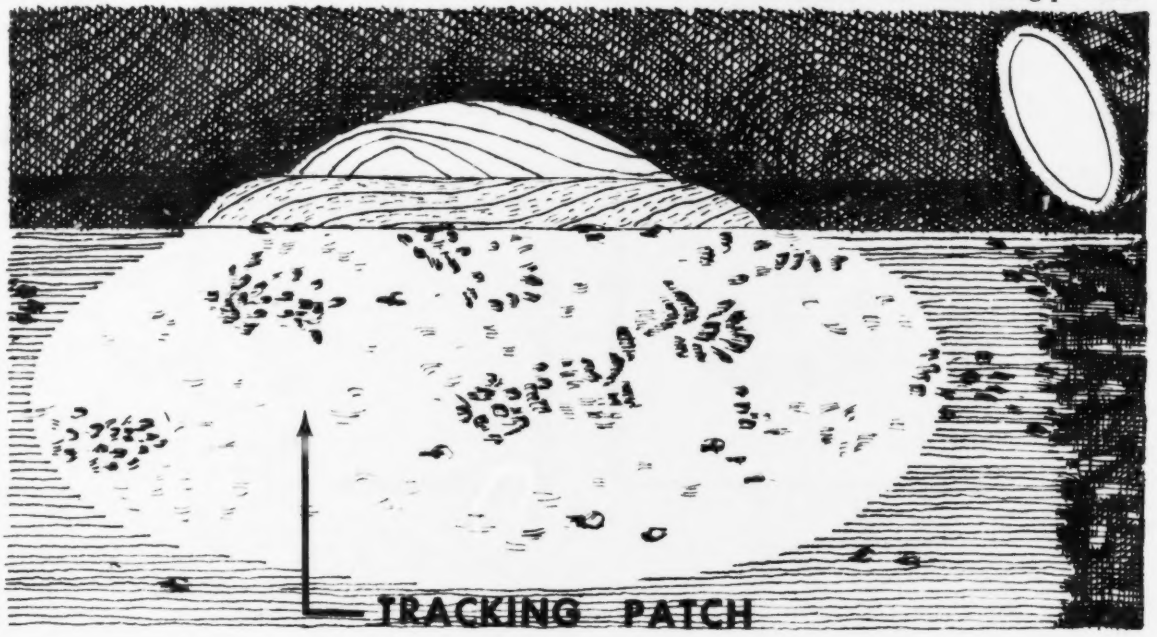
The Norway rat prefers burrows for nesting and harborage; the roof rat burrows only occasionally. Burrows are found in earth banks, along walls, under rubbish or concrete slabs, and in similar places. If a burrow is in use, its entrance will be free of cobwebs and dust. Fresh rubmarks on hardpacked soil at the opening indicate a well established and presently used burrow. The presence of fresh fragments of food or freshly dug earth at the burrow entrances also indicates current use by rats.

GNAWINGS

The incisor teeth of rats grow 4 to 5 inches a year, so these rodents must do some gnawing each day in order to keep their teeth short enough to use. Rats also gnaw to gain entrance and to obtain food. When gnawings in wood are fresh, they are light colored and show distinct teeth marks. Small chips of wood or other materials indicate recent gnawing. With age, wood gnawings become dark and smooth from weathering and from frequent contact with the rodent's body.

TRACKS

Fresh tracks are sharp and distinct, whereas old tracks are covered with dust and are therefore less distinct. The tracks of the 5-toed rear paws are more commonly observed than are those of the 4-toed front paws, but both may be present. Smooth tracking patches of any dust material, such as flour or talc, placed along runways are of value in checking for rodent activity. To see tracks in the dust, the inspector should hold a flashlight at an angle that causes the tracks to cast distinct shadows. Tail marks, too, are often visible in dust or tracking patches.



CONTROL OF RODENT POPULATIONS

BASIC PRINCIPLES

Controlling rat populations, not individual rats, is the key to a successful rodent-control program in a community. Examples of populations are the rats within a city block, those in a sewer, the rats infesting a farm, or those living in or around a feed mill. At any given time, each city block has a certain capacity to support rats. This capacity is related to the availability of food, harborage, living space and other vital rodent requirements. The rat population in a block cannot long be greater than this capacity. Permanent reduction of one or more vital factors in the block, particularly food, will result in a permanent reduction in the rodent population.

POPULATION FORCES

Forces that determine the size of a rodent population at a given time are: reproduction, mortality, and movements into or out of an area. Reproduction tends to increase a population, mortality to decrease it, and movements can work either way. Rats breed during the entire year, with peaks in spring and fall. Winter is the best time to conduct a poisoning campaign on a rat population, since breeding is then at a minimum. The next best times are summer, then fall. In field tests, populations poisoned in the winter took 12 months to return to normal; those poisoned in summer, only 6 months.

POPULATION CHANGES

As rat and mouse populations increase in size, the mortality rate also increases until a state of equilibrium is reached. Increased competition due to population pressure increases the mortality and movements of rodents. Movements into or out of an area are less important in determining the size of rat populations than either reproduction or mortality. Rodents often migrate much greater distances than the limits of their normal home range (rats 100-150 feet, mice 10-30 feet) as, for example, their annual movement from fields to buildings in the fall and then back to the fields in the spring; and their migrations when their usual sources of food are cut off, or when they are flooded out or burned out.

LIMITING FACTORS

The factors that control the balance between reproduction, mortality, and movement of rodents are: the physical environment, predation and parasitism, and competition.

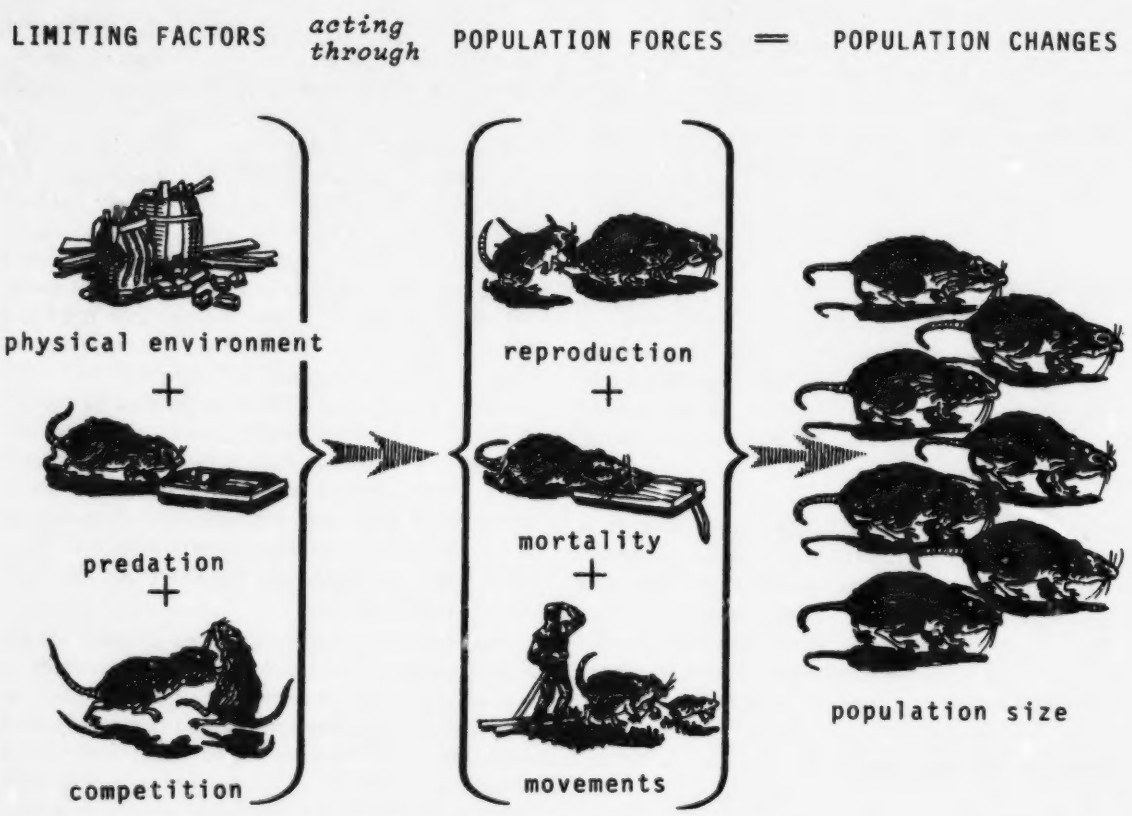
The physical environment is comprised of three main elements: (1) food and water, (2) harborage, and (3) climate. Improperly handled foods, garbage, and field crops often are major sources of rodent food. (Favorite foods and harborage for rodents are listed on page 4 under "Description and Habits of Domestic Rats and Mice.") Climate directly affects the number of rodents able to survive outdoors but has little or no effect on those living in heated buildings. A given environment can support only a certain number of animals. Generally speaking, areas with warm, moist climates are favorable, while those with dry, cold climates are unfavorable. ***Man can reduce rodent populations and keep them low by permanently eliminating their food, water, and harborage.***

Competition, whether between members of the same species or between two or more species, is one of the most important factors limiting rat populations. Norway rats compete intensely with roof rats and have replaced them over large areas, particularly in many cities where both once were found. Competition among members of the same species is very closely associated with the social organization of a population. A definite social order, or hierarchy, exists among rats and mice. This social order is determined largely by fighting, and the most aggressive animals in a population are dominant. Others are killed or are forced to move. Those that move may suffer even higher mortality from predators and resident rodents in the new areas. The strife caused by increased population pres-

sure lowers reproduction, increases mortality, and decreases the population.

The effect of predators and parasites on reduction of rodent populations appears to be temporary. This includes the predatory activities of man, dogs, cats, foxes, rats, birds, snakes and other foes, and the parasitic activities of bacteria, rickettsia, spirochetes, protozoa, and worms.

In summary, the most lasting control can be achieved *by increasing competition and predation through permanent alterations of the physical environment. In other words, environmental sanitation is the first and foremost requirement for rodent control.*



SANITATION FOR RAT AND MOUSE CONTROL

Improper storage of refuse (garbage and rubbish) and of food in the home and in business establishments invites rats to infest blocks and neighborhoods. Rat and mouse populations are controlled by the use of garbage grinders or the storage of all refuse in rodent-proof containers, the satisfactory collection and disposal of refuse, and the proper storage of usable materials. Structural harborage, such as small protected enclosures under cabinets, shelves, and stairs, should be eliminated. ***Permanent removal of harborage and sources of food will eliminate existing rat and mouse populations.***

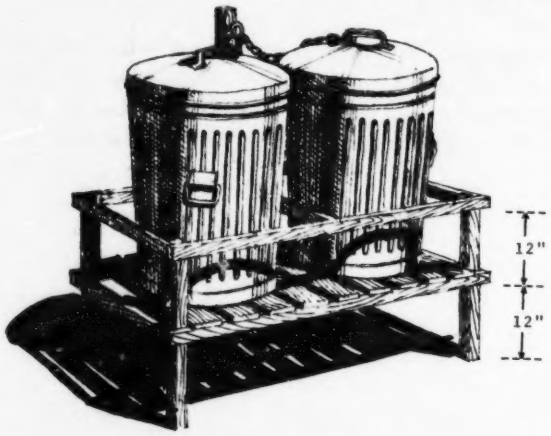
STORAGE OF REFUSE

Refuse storage facilities should include enough containers to hold all garbage and rubbish that normally accumulates between collection days. A good refuse container should be:

1. Rust-resistant
2. Water-tight
3. Tightly covered
4. Easy to clean
5. Easily handled by one man
6. Of rat- and damage-resistant construction (heavy-duty)
7. With a recessed bottom

Recommended container capacity:

For garbage only	5-12 gallons
For combined garbage and rubbish	20-32 gallons

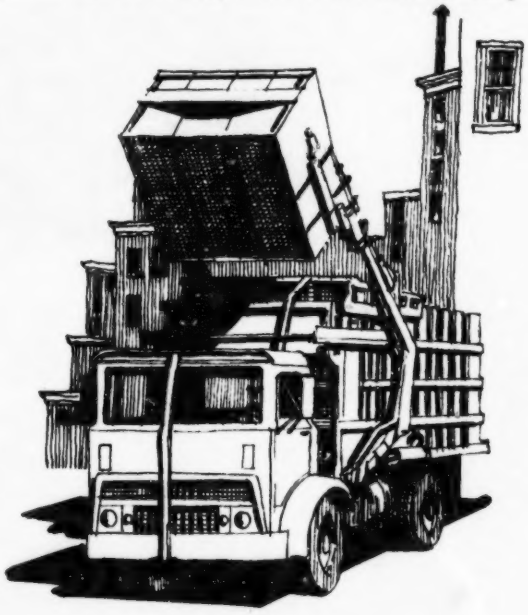


Fifty-five-gallon drums should not be used for refuse containers. When filled they are too heavy and too clumsy to handle, and they either have no lids or the lids are not tight.

Recently, units using suspended single-service paper bags for refuse storage have been tested in various communities. Since new bags are used for each collection period, sanitation is improved, collection labor is reduced, and additional bags can be used to handle unusual quantities of refuse.

Some communities have inaugurated refuse collection systems utilizing rat-proof storage containers with a capacity of several yards each. These containers are regularly emptied into a large compactor vehicle, which transports the refuse from several containers to a sanitary

landfill or an incinerator. They are available in various sizes appropriate for use in markets. apartments, schools, and other large food-handling establishments. Some of the larger units are equipped with mechanical compactors to reduce the volume of refuse and thereby increase their capacity. A special truck is required for servicing these units mechanically.



Draining and wrapping household garbage before placing it in refuse containers:

1. Reduces fly breeding
2. Reduces odors
3. Prevents garbage from sticking or freezing to the sides of the container, thus avoiding damage to cans (from bumping to loosen garbage)
4. Reduces cleaning frequency
5. Adds to the useful life of the container.

The practice of wrapping garbage is not practical for all food-handling establishments. However, special low-cost, waterproof garbage bags designed to fit standard-size containers are available commercially.

All containers should be washed or steam cleaned often enough to prevent fly and odor problems.

STORAGE OF USABLE MATERIALS

Proper storage of usable materials reduces the food and harborage available to rodents to a minimum. All packaged bulk foodstuffs should be stacked 12 to 18 inches off the floor. Unless used promptly, foods removed from commercial packaging should be stored in covered glass or metal containers. All food scraps left after meals should be collected and placed in a covered refuse container.

Sweeping floors at frequent intervals helps to reduce rodent food and permits ready detection of fresh rodent signs. In food-handling locations, a white band 6 inches wide painted along the floor next to the wall speeds the discovery of rodent droppings, rodent tracks, and other signs indicating the presence of rats and mice.

Thorough inspections should be made regularly to detect any new evidence of rodent infestation. Remember, effective and permanent control of rats and mice can be attained only through a *continuous sanitation program.*

COLLECTION OF REFUSE

Good refuse storage practices are dependent upon efficient refuse collection service. Twice-weekly collection of residential garbage, or of combined garbage and rubbish, is recommended to prevent the overloading of individual storage facilities, which provides exposed food for rats and a breeding medium for flies. Daily collection of refuse is recommended for business sections.

Four garbage storage and collection systems were studied in California, and the percentages of containers producing excessive numbers of flies were found to be as follows: 67%, with metal cans and once-a-week collection; 25%, with disposable paper bags and once-a-week collection; 10%, with metal cans and twice-a-week collection; and almost no fly production with disposable bags and twice-a-week collection. An economic evaluation of these systems, based on a time-and-motion study of pickup service in four comparable areas, showed a manpower savings of up to 30% when paper bags were substituted for metal cans. However, unless the collection system is actually designed around the concept of paper bags, the savings in time does not equal the cost of the paper bags.

Compactor-type trucks are the equipment of choice for collection, because they: (1) prevent contents from blowing or spilling out, (2) are leakproof, and (3) are easy to load and unload.

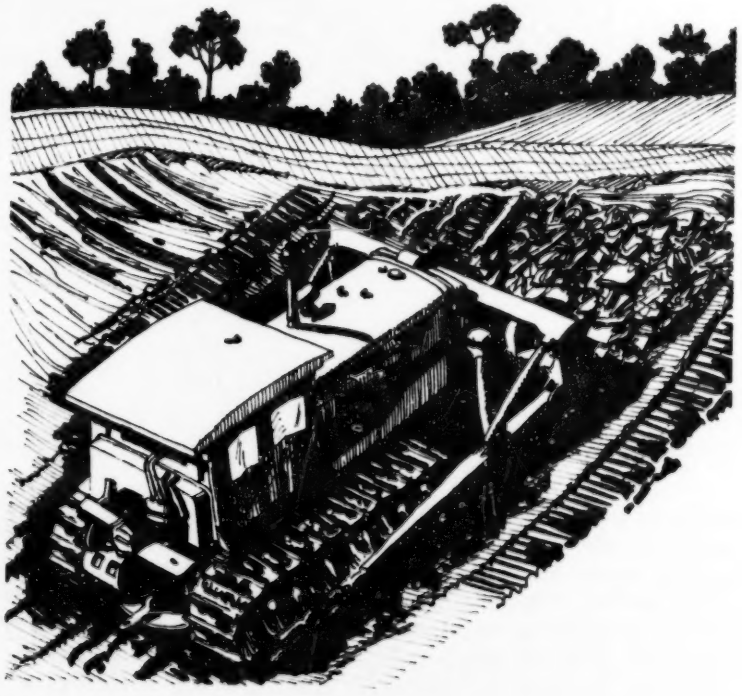
DISPOSAL OF REFUSE

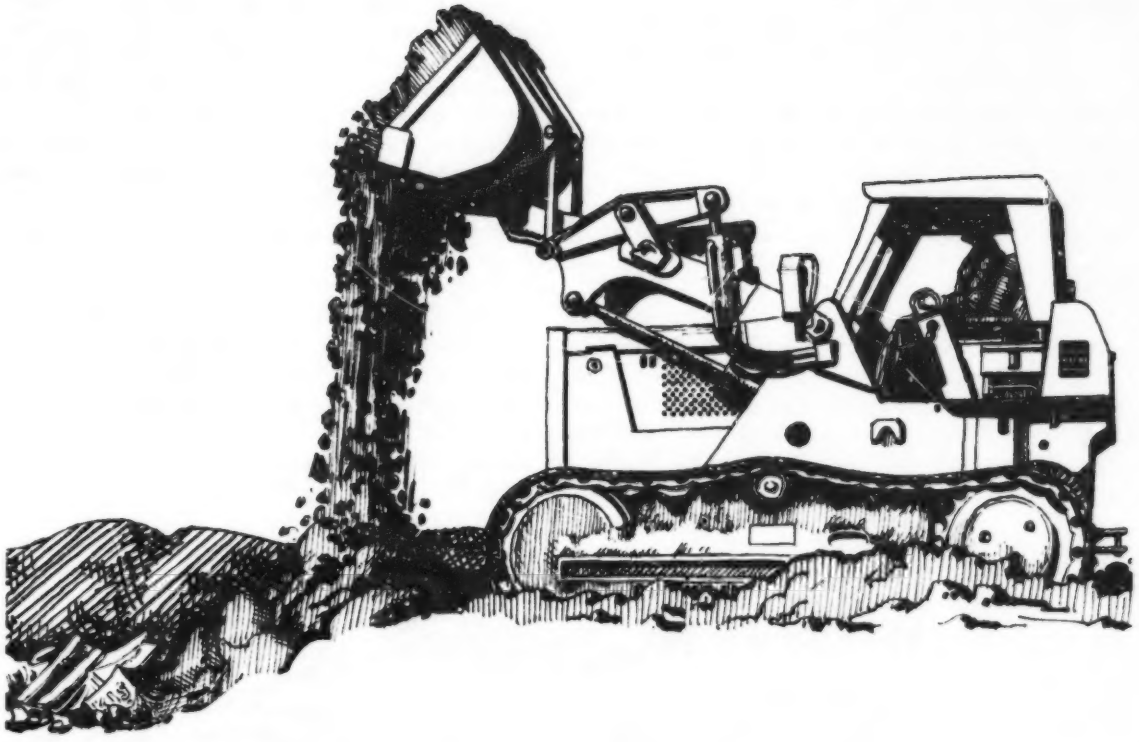
Refuse dumps and areas where hogs are fed on garbage are major producers of flies and rats, which migrate from these unsatisfactory disposal sites to adjacent cities and farms. When the rats' daily source of food at such a site is cut off, as by a snowstorm or a refuse-collectors' strike, great numbers of the rats soon migrate elsewhere. Unfortunately, many cities have insanitary, rat-infested, burning dumps. Until a sanitary method of disposal is instituted, it is often necessary to poison rats periodically to reduce the population and attempt to prevent migrations (see page 17).

The sanitary landfill and incineration methods of refuse disposal can be operated so that conditions favorable to rat production do not develop. At a properly operated sanitary landfill, garbage and rubbish are compacted and covered with earth *daily*. Local officials must demonstrate continuing interest in and support of a model operation by providing adequate financing, by visiting it frequently, and by making it a showplace for visiting officials. Modern incinerators operating at high temperatures completely burn combined refuse, thus leaving a residue that does not furnish food for rats.

Where sewer systems are adequate, electric garbage grinders provide sanitary disposal of garbage. However, this leaves other rubbish such as cans and bottles, which must be collected regularly.

Research has shown that composting municipal wastes is feasible and that it can meet public health requirements for sanitary disposal. Costs of composting are higher than with the sanitary landfill but lower than with the incinerator operation. Composting permits the salvage of some noncompostible materials such as metals and rags, and produces an end product, humus, that can be sold as a soil-conditioner supplement to fertilizers. However, composting is primarily a method of sanitary refuse disposal rather than a source of income or a method of satisfying an agricultural need. Despite considerable investment and the application of advanced techniques, no large-scale composting plant has operated economically for a long enough time in the United States to indicate success.





REFUSE AND SEWER RATS

Rats often enter sewers at outlets and through manholes, catch basins, broken pipes, or drains. They nest in earth at or near such locations. In the sewers, the rats feed on floating organic matter or that stranded or adhering to the bottom or sides of pipes, especially during periods of low sewage flow. The problem is usually greatest where storm and sanitary sewers are combined. The domestic sewage of an average community furnishes ample food for sizable rat populations. The number of rats in sewers will probably increase in this country as the expanding use of garbage grinders increases the food content of inadequate sewers. However, the net effect of garbage grinders is to reduce rats and improve community sanitation.

RELATION TO OTHER CONTROL PROCEDURES

In the community rodent-control program, rodent killing is an important adjunct to improvements in sanitation and other environmental factors. However, timing is of great importance; and control through killing alone does not endure. For these reasons, killing methods can be applied most effectively:

1. **Before** sanitation or cleanup programs are begun—to prevent mass movement and spread of rodents.
2. **After** dusting with 10-percent DDT or other insecticide recommended for flea control—to reduce rodent populations, which are the reservoirs of plague and murine typhus.
3. **During and after, or together with,** ratproofing work—to eradicate rodents in buildings.
4. **Early** in community programs—to stimulate public interest in rodent control.

Rat killing without environmental improvements, particularly good sanitation, is ineffective because:

1. Rats and mice rapidly regain the original population level through their high birth rate and the greater survival of young as a result of less competition.
2. A continuous killing program is necessary, which is costly in terms of labor and materials.
3. Continued use of most poisons can result in bait shyness.

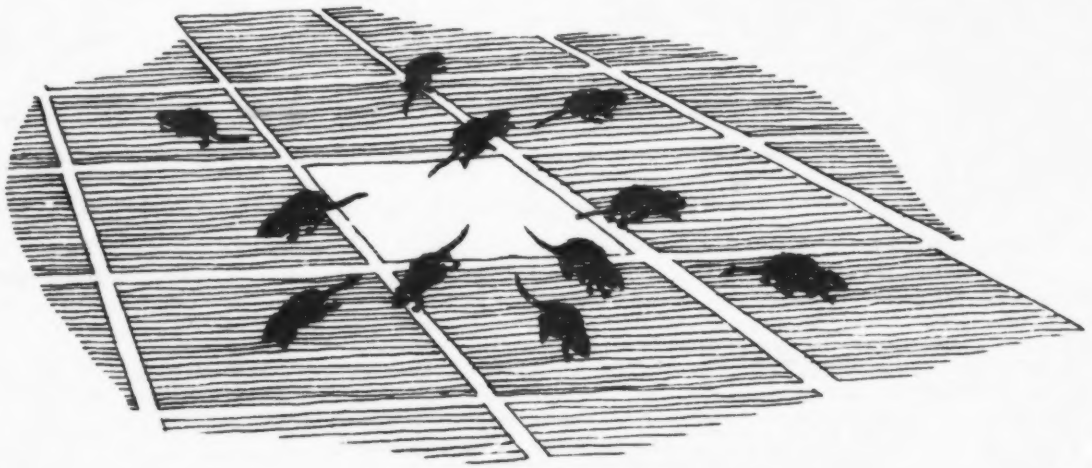
POISONS AND BAITS*

POISONS AND THEIR MODES OF ACTION

The anticoagulants, red squill, and zinc phosphide are the rodenticides generally recommended for use by health departments and by the public. These rodenticides are available commercially and are the ones with which the untrained individual is the least likely to experience difficulties.

The anticoagulant rodenticides, such as warfarin, Pival, Fumarin, and diphacinone, kill in a radically different manner from the older acute (single dose) poisons. They must be ingested for several consecutive days before they become effective. This provides a definite safety factor for a child or an animal that may eat a single large portion of anticoagulant bait. The anticoagulant poisons cause internal hemorrhages, so the poisoned rodents literally "bleed to death." Even when weakened, the rats apparently do not associate their condition with the food supply and will return again and again to feed on anticoagulant-treated baits. So the problem of bait shyness commonly associated with

*See pages 18 and 19 for table of rodenticides.



SOME CHARACTERISTICS

POISONS	Lethal Dose (Mg/Kg)	Percent Used in Bait	Degree of Effectiveness	Acceptance	Reacceptance	Cumulative	Tolerance Developed	Odor	Taste	Chemical Deterioration in Baits
ANTICOAGULANTS Warfarin Fumarin Pival • • •	1[1]	.025	Good	Good	Good	Yes	No	None	Slight	None
ANTICOAGULANT Diphacinone • • •	0.5[1]	.005	Good	Good	Good	Yes	No	None	Slight	None
ANTU •	8[2]	1.5	Good	Good	Poor	No	Yes	Slight	Medium	Slight
ARSENIC • •	100[3]	3.0	Fair	Fair	Fair	No	Yes	None	Medium[4]	None
FLUOROACETAMIDE (1081) • • •	15–Norway 51–Mice	2.0	Good	Good	Good	No	No	None	Slight	Slight
PHOSPHORUS, YELLOW • •	1.7	.05[4]	Good	Good	Fair	No	No	Strong	Strong	Fast
RED SQUILL •	500[5]	10.0	Fair	Fair	Poor	No	No	Medium	Strong[4]	Medium
SODIUM FLUOROACETATE (1080) • • •	5–Norway 2–Roof R. 10–Mice	1/2 Oz./Gal. 1 Oz./28 Lbs.	Good	Good	Good	No	No	None	Slight	Slight
STRYCHNINE (Alkaloid) • • • •	6	0.6	Fair	Fair	Poor	No	Yes	None	Strong[6]	Slight
STRYCHNINE (Sulfate) • • • •	8	0.8	Fair	Fair	Poor	No	Yes	None	Strong[6]	Slight
ZINC PHOSPHIDE • • •	40	1.0	Good	Good	Good	No	No	Strong	Strong	Fast

• Effective against Norway Rats only
• • Effective against Norway Rats and Roof Rats
• • • Effective against Norway Rats, Roof Rats, and House Mice
• • • • Mice only

1. More or less. Successive doses required for 5-10 days or more.
2. Norway rats only, on first exposure.
3. Particle sizes of USP grades vary widely; some coarse powders test as high as 600 Mg., micronized at 25 Mg.; latter recommended, at 1.5 percent.
4. Commercial preparations vary from 1-3% in paste form, use as label directs.

OF COMMON RODENTICIDES

Solubility		Type of Bait Mixtures			ACTION (Cause of Death)	Relation to Humans and to Other Animals			ANTIDOTES[8]
Water	Oil	Dry	Fresh	Water		Secondary Poisoning	Absorbed thru Skin	Degree of Hazard in Use	
Yes	Yes	Yes	No	Yes	Inhibits clotting of blood; causes internal hemorrhages. ■	Yes	No	Slight	Vitamin K and transfusions of whole blood.
No	Yes	Yes	No	No	Inhibits clotting of blood; causes internal hemorrhages. ■	Yes	No	Slight	Vitamin K and transfusions of whole blood.
No	No	Yes	Yes	No	Pleural effusion (over-production of fluid in the lungs). ■	No	No	Medium	None
Yes	No	No	Yes	Yes	Kidney destruction; Gastro-enteritis; Central nervous system affected. ■	No	No[7]	Medium	Milk of magnesia, milk, and water; Oxide of iron.
Yes	No	No	Yes	Yes	Similar to sodium fluoroacetate (1080). ■■	Yes	No[7]	Extreme	None
No	Yes	Yes	No	No	Heart paralysis; Gastro-intestinal and liver damage. ■■	No	No	Medium	Copper sulfate before emetic; Cathartic and water. Avoid fats and oils (as milk).
Yes	Yes	Yes	Yes	Yes	Heart paralysis. ■	No	No	Slight	Acts as own emetic to animals capable of vomiting.
Yes	No	No	Yes	Yes	Paralysis of heart and the central nervous system ■■	Yes	No[7]	Extreme	NONE. Monoacetin or ethyl alcohol and acetic acid recommended.
Yes	No	Yes	No	No	Convulsions due to super-stimulation of nervous system; exhaustion; asphyxia. ■■■	No	No	Medium	No emetic after 10 minutes. Charcoal in water and sedative; Keep in dark room.
Yes	No	Yes	No	No	Convulsions due to super-stimulation of nervous system; exhaustion; asphyxia. ■■■	No	No	Medium	No emetic after 10 minutes. Charcoal in water and sedative; Keep in dark room.
No	Yes	Yes	Yes	No	Same as phosphorus. ■■	No	No	Medium	Same as phosphorus.

■ Slow acting
■■ Fast acting
■■■ Very fast acting

5. Minimum acceptable level; more toxic squills give better results.
6. Normally objectionable to rats.
7. Can be taken through cuts or breaks in the skin; also danger of inhaling loose powder.
8. Emetics used as first aid except as noted; speed is essential; 1 tablespoon of salt in a glass of warm water is usually effective; call a physician immediately.

Modified from U. S. Dept. of Interior, Fish and Wildlife Service Leaflet #337, Revised Dec. 1959

"one shot" poisons is largely overcome. Nonfatal doses of acute poisons are often painful, whereas anticoagulants apparently cause no pain.

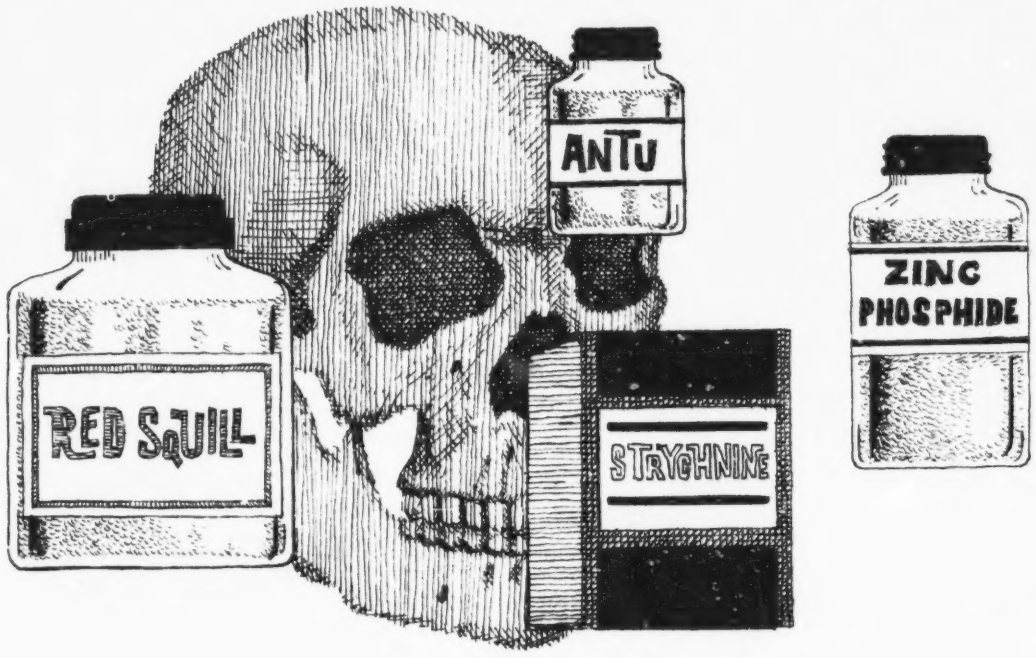
Red squill has a bitter taste and a natural emetic action, factors that contribute to its safe use as a rodenticide. Rodents, unlike humans and most domestic animals, are unable to vomit and are therefore not protected by the emetic quality of red squill, which kills them by paralyzing the heart. This poison is not well accepted by roof rats and house mice, but it can be used effectively against Norway rat populations if exposed in a very attractive bait at the start of a killing campaign. However, because of red squill's bitter taste, bait shyness may soon become a problem.

Commercial squills vary considerably in strength, so it is important to buy only a *fortified* squill. Red squill fortified to an LD_{50} of 500 mg/kg has given high percentage kills when thoroughly mixed 10% by weight with a *fresh attractive bait material.* A more toxic squill (LD_{50} of 250 mg/kg), mixed similarly at 5% by weight, is recommended to increase acceptance and enhance results.

Red squill is hygroscopic, that is, it absorbs water from the atmosphere, so if it is exposed to the air it becomes caked and hard. Therefore, red squill should be protected by storing it in tightly sealed containers.

ANTU (Alpha-naphthylthiourea), if used properly, is effective as a quick-acting poison for the Norway rat. It causes an overproduction of fluid in the lungs of the rat, and the poisoned animal dies by drowning, usually within 48 hours. As with red squill, it is not effective for the control of roof rats or mice. Rats are strongly reluctant to accept repeated doses of ANTU, and they develop a marked tolerance for it. Consequently, this poison should not be used against the same rat populations more often than once a year. Therefore, the single annual baiting must be thorough. ANTU has a good safety record where humans are concerned, but *dogs, cats, and hogs are readily poisoned by it, so great care in placement of baits is necessary.*

The offensive odor and unattractive color of the more toxic **zinc phosphide** serve as safety factors for it. Despite these characteristics, Norway rats, roof rats, and house mice seem to like the taste and pungent odor of the phosphorus. It kills them by causing heart paralysis and gastrointestinal and liver damage. Although most



well-fed domestic animals will not touch baits prepared with zinc phosphide, it is nonetheless a hazard to all animals and should be used with care.

Sodium fluoroacetate, 1080 ($CH_2FCOONa$), is very poisonous and very fast acting, usually producing symptoms in rats in 20 minutes or less and killing them within 1 to 8 hours. It is extremely dangerous to use, and its use is therefore restricted almost entirely to bonded professional operators. Rats poisoned with 1080 may develop convulsions from its action on the nervous system, but death usually results from heart failure.

Fluoroacetamide, 1081 (FCH_2COHN_2), a rodenticide closely related to sodium fluoroacetate (1080), has been registered with the U. S. Department of Agriculture for poisoning rats in sewers. British researchers consider it safer to manufacture and handle and more efficient in use than 1080. They found it an effective and well accepted rodenticide for *R. rattus*, *R. norvegicus*, and *M. musculus* when mixed 1 or 2 percent in water or feed baits.

The period of onset of warning symptoms with 1081 is longer than with 1080, with the result that rats consumed from 18 to 100 lethal doses before becoming distressed. Therefore fluoroacetamide is believed less likely than 1080 to lead to poison-shy rats because sublethal amounts of bait are ingested. Fluoroacetamide is available from the manufacturer as a water bait and as a ready-to-use dry bait. Although it is less toxic than 1080, it is nonetheless a highly toxic compound and the same handling precautions followed for 1080 apply to fluoroacetamide.

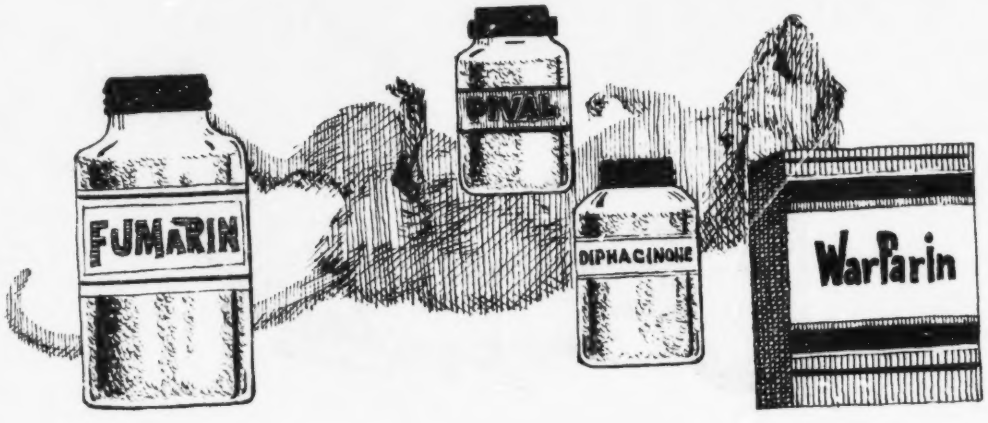
Sodium fluoroacetate (1080) and fluoroacetamide (1081) are the most effective and the fastest acting rodenticides. Because of their extreme toxicity to man and animals, they should be used *only* on certain types of premises and *only* by competent specialists. These professional operators know the precautions and the very strict limitations to be observed in the use of these poisons.

SUGGESTED BAIT FORMULAS

Anticoagulants (warfarin, Pival, and Fumarin 0.025% ; diphacinone 0.005%) are effective in a variety of simple, inexpensive, meal-type baits such as yellow corn meal, rolled oats, or a combination of the two. Advantages of these bait materials are: (1) low cost, (2) ready acceptance by rodents, and (3) good keeping qualities.

Materials	Parts by Weight	Amount
Poison (0.5% concentrate)	1 part	1 lb.
Yellow corn meal	19 parts	19 lbs.

Where rodents do not accept this formula, replace 7 parts of the yellow corn meal with 5 parts of rolled oats, 1 part of granulated sugar, and 1 part of corn oil. This mixture is more expensive but should increase acceptance by rodents. A discoloring agent such as charcoal may also be added. The chances of failure in control of mice, which nibble when they feed, can be reduced by using relatively high dosages



of anticoagulant, by weight: 1 part concentrate to 9 parts corn meal (0.5% concentrate when using warfarin, Pival, or Fumarin, but 0.1% concentrate when using diphacinone).

Anticoagulants are available as water-soluble baits, which should be mixed according to instructions on the label. Field trials in England suggest that the combined use of anticoagulant solution baiting stations surrounded by a dust of anticoagulant concentrate is a valuable additional method of controlling house mice, particularly those living in warm, dry environments.

Note:

Rats and mice are attracted to sweets. A small amount of sugar, molasses, syrup, raisins, or sweetened fruits will increase acceptance when added to food or water baits. However, this also increases the attractiveness of baits to ants and other insects and may thereby reduce their acceptability to rodents.

Single-Dose Poisons

• Red Squill	5% or 10%	Amount
Poison (fortified)		
500 mg/kg	or	1 lb.
250 mg/kg		1 lb.
Bait: ground fresh meat, bacon, fresh or canned fish, grains, cereals, selected fresh fruits or vegetables, or combinations of these (see p. 24).		
with 500 mg/kg squill	or	9 lbs.
with 250 mg/kg squill		up to 19 lbs.
Binder (optional) as required to hold bait together (see page 24)		
Discoloring agent (optional)		

• Zinc Phosphide	1%	Amount
Poison		4 oz.
Bait: (Same selection as for Red Squill)		25 lbs.
Tartar emetic		1½ oz.

Zinc phosphide is often used to coat ½-inch cubes of sweet potato or apple for use as baits. To mix, put the freshly cut, moist cubes in a wide pan with the poison, then using a long handled spoon, mix until all of the poison has been taken up by the cubes.

• ANTU	1.5%	Amount
Poison		8 oz.
Bait: (Same selection as for Red Squill)		33 lbs.
Discoloring agent (optional)		

- Strychnine (for house mouse control only) Poison is available from manufacturers as a prepared product consisting of colored wheat grains or canary seed coated or impregnated with strychnine.

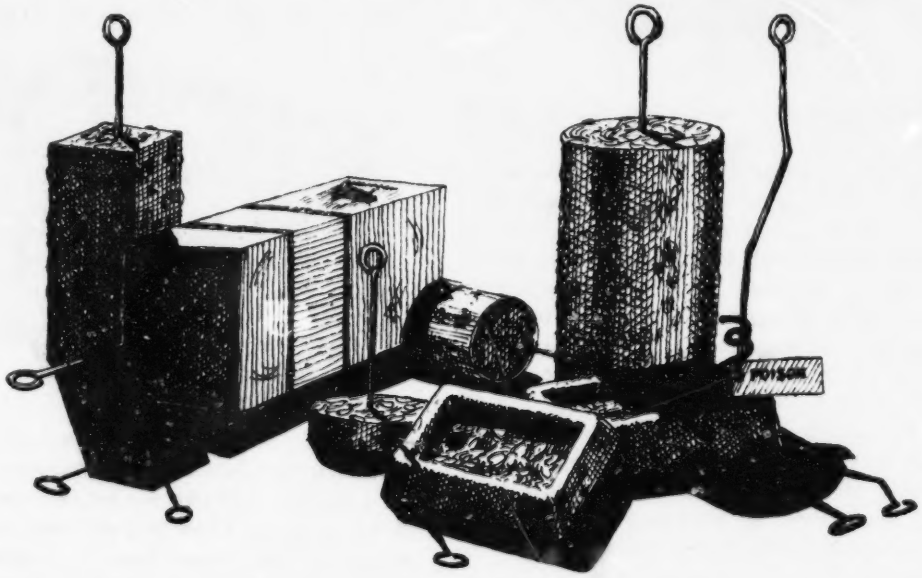
- DDT (50%, finely powdered) dusted along runways is effective for mouse control. Care must be taken that foodstuffs do not become contaminated.

Paraffin Formulations—For poisoning rats in sewers and other humid areas, sufficient melted paraffin is added to coat anticoagulant or single-dose poison-grain mixtures. When solidified, such bait mixtures shed water, resist mildew and insect infestation, and keep bait fresh for several weeks.

In formulating these baits, add up to 1½ pounds (maximum) of melted paraffin to 2¾ pounds of a grain-and-poison mixture in a container suitable as a mold, for example, a discarded paper milk carton, which can be torn away after the mixture has set. Let one end of a short piece of wire hang in the mixture as it solidifies, and make a small loop, or eye, in the other end so that additional wire can be added, as needed, to permit lowering the bait block into the sewer and securing it there.

In dry locations, rodent acceptance of these paraffin bait formulations may not be as good as with conventional mixtures. However, reports indicate good results in the use of rodenticide-bait-paraffin mixtures to control rats in sewers where conventional mixtures cannot be used.

Some grains, such as oats, and some rodenticides, such as Pival, are reported to inhibit mildew. Also, preservatives such as 0.025 percent DuPont DDPD and 0.1 percent 2,4,5-trichlorophenylacetate have been added to baits to extend the period of overall acceptability, but they also reduce the taste acceptability to rodents. British workers found no evidence that poisoning treatments improved through use of mold-inhibiting substances.



PREPARATION OF BAITS

Suggested materials for baits include: fresh, frozen, or canned meats, fish, or pet food; bacon, yellow corn meal, cracked corn, hulled oats, rolled oats, canary seed (for mice), apple, sweet potato, melon, tomato, peanut butter, nutmeats, and butter.

Fresh baits are the most acceptable to rats and mice, so mix only enough bait for current needs.

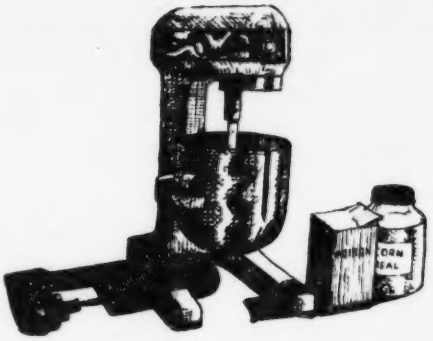
A binder of molasses or of vegetable, mineral, or fish oil is often used in cereal or dry baits to hold the poison and the dry bait together and to aid in mixing.

An emetic, usually tartar emetic, is mixed with zinc phosphide and other more toxic bait formulations to protect animals other than rodents, even though acceptability of such baits to the rodents is thereby reduced. Rats are among the few animals that are unable to vomit.

Mix bait as directed. Too much poison may give the bait a strong taste or odor. Too little will not kill but may result in "bait shyness." Excessive amounts of poison increase the danger to man and to domestic animals.

Mix baits well. Poor mixing results in nonuniform baits and poor kills, and speeds development of bait shyness. Mechanical bait-mixing equipment is necessary where large quantities of bait are mixed routinely.

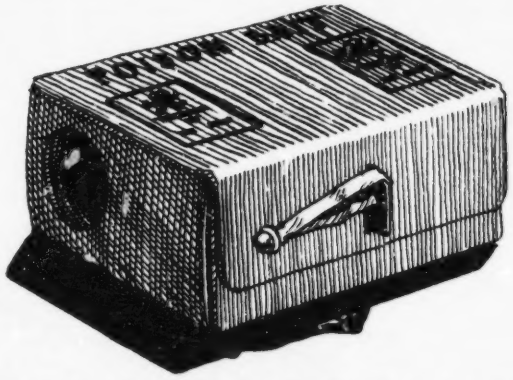
• **CAUTION:** Clearly label poisons and mixing equipment. Do not use bait-mixing equipment for other purposes. Lock up poisons and mixing equipment when not in use.



• **CAUTION:** Treat all poisons with respect. Read and follow all label instructions. Avoid inhaling powders or getting poisons on hands, clothes, or utensils from which they may reach the mouth. Wear rubber gloves when handling poisons. Always mix poisons in a well-ventilated place, particularly when mixing dry ingredients.

BAIT PLACEMENT

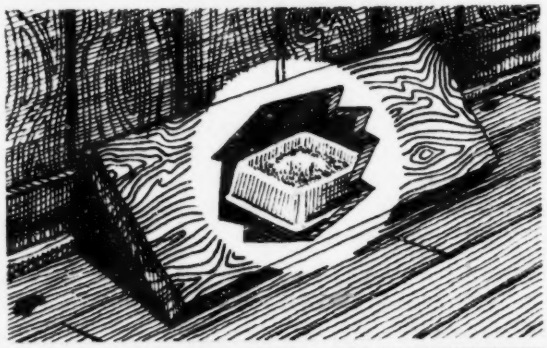
Anticoagulant Baits. Anticoagulants are not "one-shot" poisons, so they require a different method of use from other rodenticides (see page 17). Bait mixtures are frequently placed in paper, metal, or plastic pie plates or in permanent bait stations. The number of pie plates or bait stations would vary with the infestation. Small pie plates will hold ¼ to ½ pound, whereas permanent bait stations often hold over

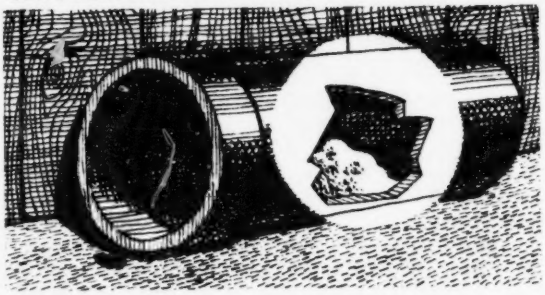


a pound of bait mixture. Be liberal in baiting. Anticoagulant bait mixtures are usually exposed for a minimum of two weeks; but where reinfestation is likely, a few bait stations may be maintained on a permanent basis. For anticoagulants to be fully effective, repeated doses must be consumed by every rodent at a given location for a period of five or more consecutive days.

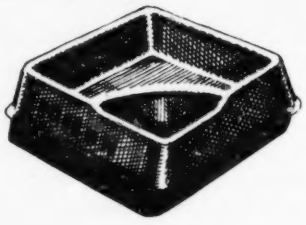
Therefore, observe the following instructions:

1. Protect animals other than domestic rodents, and shield baits from the weather under shelter or with bait boxes, boards, pipes, or cans.
2. Note locations of all bait containers so that inspections can be made rapidly and the bait that has been consumed can be quickly replaced. (Note: Bait consumption is generally heavy right after initial placement, making daily inspection and replacement advisable for the first 3 days after regular feeding begins.)
3. At each inspection, smooth the surface of the baits so that new signs of feeding will show readily.
4. Replace moldy, wet, caked, or insect-infested baits with fresh ones.
5. If a bait remains undisturbed for several successive inspections, move it to an area showing fresh rodent signs.

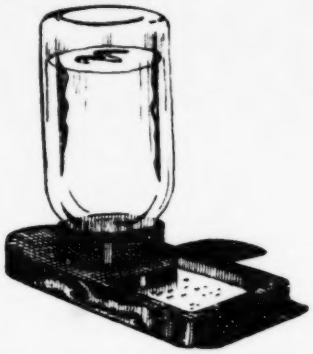




Use shallow bait containers fastened to the floor, or containers of sufficient weight to prevent the rodents from overturning them or dragging them to their burrows. A roofing tack driven through metal or fiber containers into the floor reduces spillage.



Poisoned Water. When poisoned water is used, place it only where other animals cannot get to it. Use containers that will not spill, such as glass caster cups or low metal or water-resistant paper cups. Chicken founts are satisfactory for permanent stations. *Note:* Water baits are most effective where other sources of water are limited or can be eliminated, as in feed mills or granaries. British workers report that the use of anticoagulant dust concentrate placed in a patch around anticoagulant poison water stations is effective in mouse control.



Single-Dose Poisons. Wrap one-shot poison food baits in 4" x 4" paper squares to form "torpedoes" about the size of a large olive. One pound of bait will make about 80 to 90 such torpedoes. These may be tossed readily into otherwise inaccessible places. Rats prefer to carry their food to their harborage to eat it in safety. If several types of bait such as meat, fish, or cereal are to be distributed at the same time, a different color of paper should be used for each of the various types of bait.

Be generous with baits. Remember, rodents have a limited "home range," usually less than 150 feet for rats and 30 feet for mice. Too few baits, or poorly placed baits, may miss many rodents. Bait liberally where signs of rat activity are numerous and recent. In light or moderate infestations, torpedoes containing a single-dose poison, such as red squill, have given good control when applied at a minimum rate of 20 baits per private residence and 40 per small business establishment. As many as 100 to 200 baits may be required for premises with heavy rodent infestations. *Place baits in hidden sites out of reach of children and pets.* Inspect and rebait as needed, using another poison and another bait material when the rats become shy of the original baits.

"Throw Bags," which are bags of paper, moisture-resistant paper, or plastic, each containing about ¼ pound of anticoagulant or single-dose poison bait mixture, can be thrown into heavily infested sewers and into burrows and other inaccessible areas. Some operators pierce the bags in place to make the contents more accessible to rats. However, this makes it more difficult to determine the amount of bait consumed.

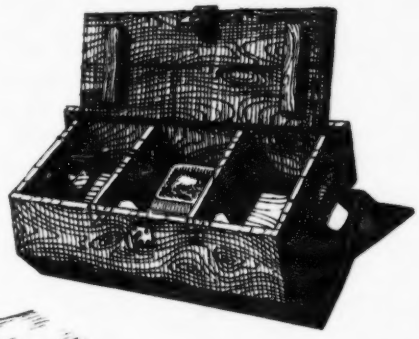
Prebaiting. When single-dose poisons are to be used, prebaiting for several nights with three or more kinds of unpoisoned baits can increase subsequent acceptance of the poison bait, particularly when rats evidence bait shyness. However, it is too costly a practice for large-scale use. As with poisoned baits, a distinguishing color of paper wrapper should be used for each type of unpoisoned bait material. Prebaiting with distinctively-colored torpedoes of three kinds of bait—for example: meat, fish, and grain—will show the preferred bait material and at the same time indicate how many baits are needed, and where.

Poisoning at Dumps. Open dumps, with their continuously replenished supply of food and harborage suitable for rodents, comprise a special problem in the rodent-control program (see page 15). Until sanitary disposal of refuse is instituted, poisoning may be the only effective means of controlling rats at these sites.

Fifty to a hundred pounds or more of poisoned bait may be required to bait a single heavily infested dump. Good results have been obtained by using the following techniques:

1. Wait about a day after the last load of refuse is deposited at the dump. Provide drinking water if none is available.
2. Using a single-dose poison, bait heavily for several nights. If rodent ectoparasites or cockroaches are a problem, power dust with a recommended insecticide.

3. On the day following the last night of single-dose poisoning, establish a number of anticoagulant rodenticide bait stations and service them regularly until all signs of rat feeding cease.
4. Level the dump and cover with earth to a depth of two feet after compaction.



Poisoning in Sewers. In sewer systems, as at open dumps, rodents find safe harborage and a constantly replenished supply of food; and, like the open dump, an infested sewer serves as a continuous source of reinfestation for nearby neighborhoods. Unless and until permanent control of sewer rodents is undertaken, by major renovation of old sewers or construction of new, a poisoning program is the only effective means of control. But results of poisoning are short-lived, and sewers must be re-treated periodically. Field trials suggest that two to four treatments per year against rats in sewers give satisfactory control.

The most satisfactory effective formulation for use in humid sewers is the paraffin-poison-bait mixture described earlier (page 23), using either an anticoagulant rodenticide or zinc phosphide as a single-dose poison. An especially provided wire, when attached to the ladder or other suitable point near the top of the manhole, prevents the bait block or bait container from lodging in the sewer and simplifies inspection of the bait station. Paraffin baits to be placed in sewers subject to overflow may be nailed or otherwise fastened to boards of sufficient size to float the can or carton of bait.

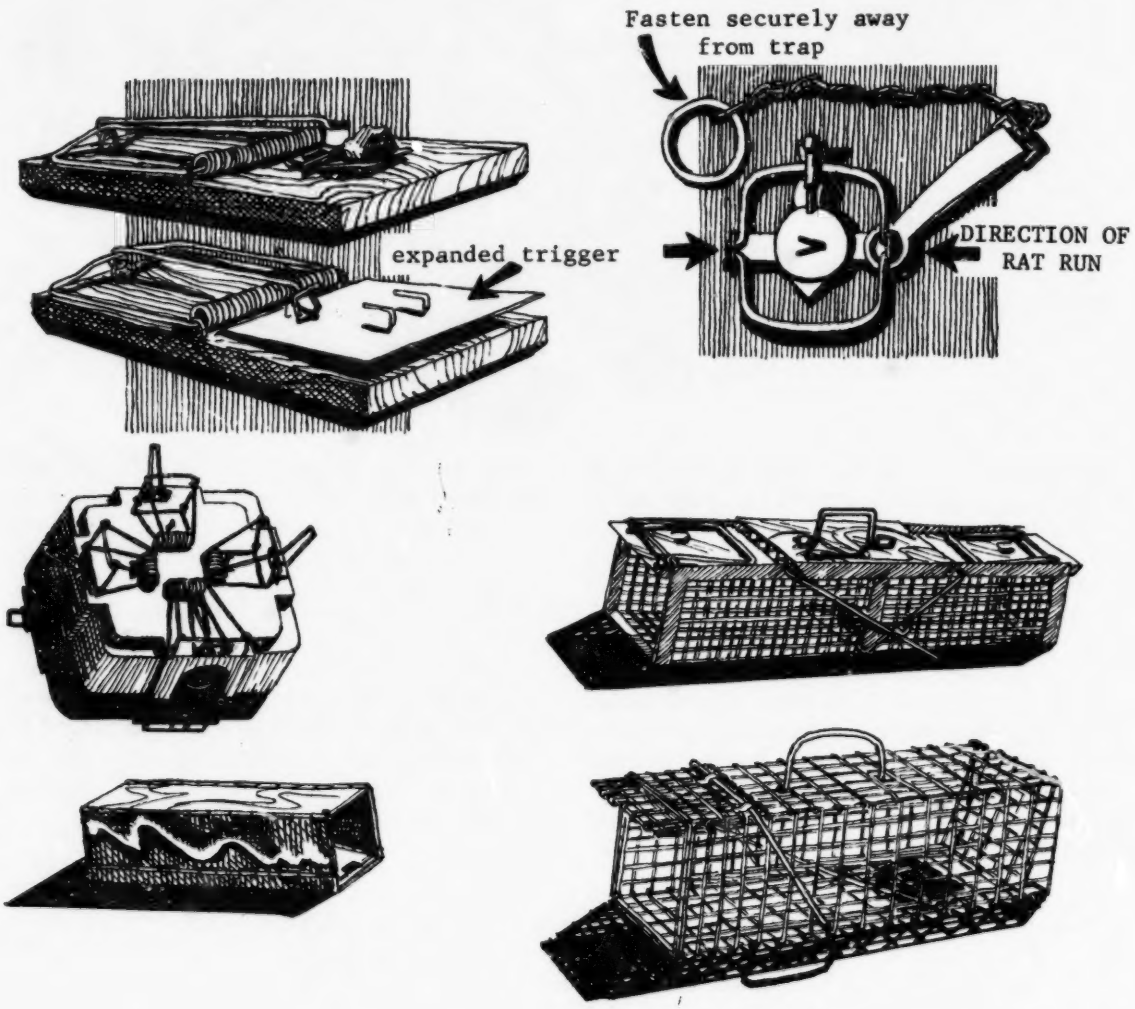
• **CAUTION:** Sewer manholes can serve as reservoirs of poisonous gases and carbon dioxide. A worker should never enter a manhole unless he has a rope tied as a lifeline around his body and helpers present to lift him to the surface, immediately, if necessary.

TRAPPING

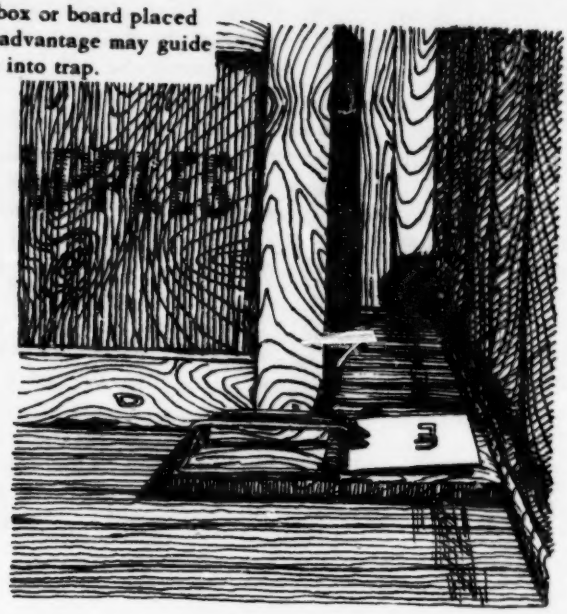
Traps are useful when poisons fail or their use is too risky, where the odor of unrecovered dead rodents would be a problem, and when live-trapped rodents are desired in order to collect rodent ectoparasites and bloods for use in disease studies. For the latter purpose, steel traps and cage-type traps should be used.

The snap trap is one of the most effective devices for killing rats and mice, particularly mice. An attractive bait should be fastened securely to the trigger. For rat control, the trigger may be expanded with cardboard or screen wire and used unbaited. Steel traps (Oneida-Victor size #0 or equivalent) are effective for catching rats alive. Set the trap with the jaws open across the runway and fasten the chain securely. Cage or box traps are usually less convenient and are not as efficient as steel traps, but they catch the rodent uninjured. Placing cage traps in dark places or covering them with material such as burlap bags will increase catches. A "choker"-type trap, properly set, may catch several mice per night.

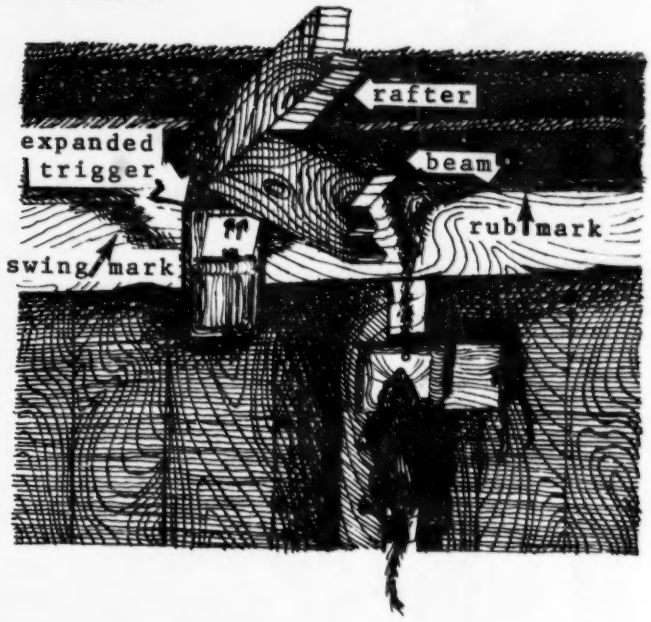
Boiling traps after use to remove the human odor is not necessary. Rats live so close to man that his odor is part of their everyday experience.

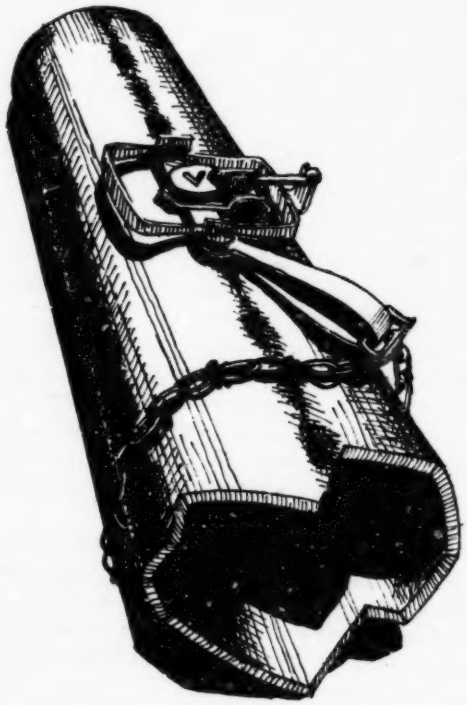


A box or board placed to advantage may guide rat into trap.



Place traps across obvious runways or where runs are confined.





Steel trap mounted over a pipe used by rats as a runway.

GASSING

Gassing of burrows is used as a supplementary measure for killing rodents. It should not be attempted by untrained operators. Several materials are available for this purpose, one being calcium cyanide. *Cyanide dust* ("A"-dust* or equivalent) is effective when it can be blown into a burrow system where rodents are concentrated. However, calcium cyanide dust is not effective when the ground is extremely dry. Some moisture is needed in either the soil or the air to convert the dust to gas.

A foot pump is an effective means of blowing calcium cyanide dust into rodent burrows. After inserting the pump hose an appreciable distance down the burrow entrance, the operator turns the valve to "dust" and pumps 2 to 6 strokes with the handle, which blows the dust into the burrow system. Then he turns the valve to "air" and pumps an additional 10 strokes or so, which forces the dust throughout the system. He watches the ground nearby for escaping dust to show him where there are other openings to the burrow system, then quickly closes and seals these auxiliary openings to prevent escape of the gas or of the rodents it is meant to kill. When a foot pump is not available for dispensing the dust, the operator can use a hand duster or a long-handled spoon. However, he must be sure to place the dust at least 8 inches down inside the burrow.

Burrows may be reopened by rats shortly after they have been gassed. This represents either a failure of the gassing operation or a new rodent infestation and indicates a need for re-treatment.

CAUTION: Cyanide fumes are highly toxic and rapidly fatal. Avoid inhaling dust or fumes. Cyanide gas is lighter than air. Therefore, burrows that may lead under occupied buildings must not be gassed. Indoor fumigation with this gas must be done only by thoroughly trained professional fumigators.

* Manufactured by American Cyanamid Co., New York, N. Y.

OTHER KILLING METHODS

Carbon monoxide gas from an automobile motor left running may sometimes be used for gassing rodent burrows. The fumes from the motor are piped through a hose running from the auto's exhaust pipe into the burrow system. All burrow entrances other than the one to be used for introducing the gas should be searched out and tightly sealed in advance of the operation, thus preventing the escape of the rodents and avoiding dilution of the gas.

This technique is extremely hazardous, however, since the fumes may be forced back through the exhaust system, and any leak in the system could let the deadly gas enter the auto and overcome the occupants. To safeguard against this danger, all car doors and windows must be left open while the motor is running.

Flooding burrows may be a productive technique and is applicable where there are tight clay soils. Water under pressure, as from a garden hose, can be used to drown rodents in their burrow or to drive them out where they can be clubbed to death.

RELATED PROBLEMS

ECTOPARASITE CONTROL

Control of ectoparasites (fleas, lice, mites, and ticks) is vital in order to prevent transfer of rodent diseases to man. Ectoparasites feed on the blood of their rodent hosts and may thereby become infected. When such hosts are killed through trapping or poisoning, their ectoparasites may, by chance, select man as a temporary host, and if they are diseased, may infect him with the organisms. When disease is thought to be present in a population of rodents, the ectoparasites must be killed *before* rodent eradication measures are begun.

To treat a building or an area for control of ectoparasites:

1. Inspect for signs of rat or mouse activity, especially for rubmarks at the base of walls, and for evidence of runways and burrows.
2. Treat all runways, burrow entrances, and nests with 10 percent DDT dust or other recommended insecticide. Dust the vertical surfaces against which the rodents may brush by using a dust gun, hand shaker, or scoop, or by hand-throwing the insecticide.

Rats that come in contact with insecticide dust carry it on their feet and fur to their burrows and nests. This gives ectoparasite control in areas beyond the reach of normal dusting activities.

As determined in past extensive county-wide dusting programs, residential premises require about 2½ pounds of 10% DDT dust per treatment and business establishments require about 4 pounds per treatment.

In controlling plague or murine typhus, the modern approach is to dust with 10% DDT to kill infected ectoparasites, particularly the oriental rat flea. The dusting operations should begin at those locations where the cases of plague or murine typhus were acquired, or are suspected of having been acquired. Treatments should then be extended to adjoining areas, as needed. For fleas resistant to DDT, 2% Diazinon, 5% malathion, or 10% carbaryl dusts can be tried.

DEAD-RODENT ODORS

Dead rodents should be removed, if possible. However, when they die in inaccessible places, the following measures may give partial or complete relief from offensive odors:

1. The use of fans will increase air circulation.

2. To mask unpleasant odors, such products as isobornyl acetate, Neutroleum Alpha, quaternary ammonium compounds, Styamine 1622, Zephiran chloride, and Bactine can be used as an aerosol, a mist spray, or in a bowl or bottle with a cotton wick.*

3. Oil of pine, oil of peppermint, oil of wintergreen, formalin, anise, or activated charcoal can also be used as masking agents or deodorants. For exampie, 10 drops of pine oil in a gallon of water can be applied with an atomizer or with a fine-mist sprayer.

4. If the dead rodent can be located, as by fixing its position between partitions or walls, a pint water mixture of one of the masking agents listed in #2 above may be poured through a small hole bored into the wall a few inches above the floor level and as close to the source of the dead-rodent odor as possible. This treatment usually dispels odors rapidly. When the precise location of a rat carcass is difficult to determine, one or more blue bottle flies (*Calliphora* spp.) released into the room can help. Guided by the odor, they will fly unerringly to the spot where the dead rat is behind the wall.

CARCASS DISPOSAL

The carcasses of all rats recovered from the poisoning, trapping, and gassing operations and all uneaten poison baits should be buried or burned. Anyone handling the dead rodents should wear rubber gloves.

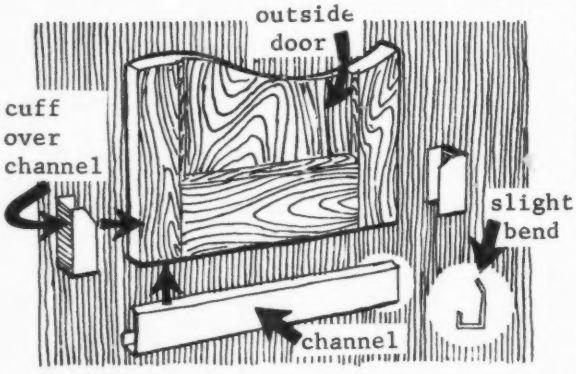
* Isobornyl acetate is manufactured by E. I. du Pont de Nemours & Co., Wilmington, Del.; Neutroleum Alpha, by Fritzsche Bros., New York, N. Y.; Styamine 1622 by Rohm & Haas, Philadelphia, Penn.

RATPROOFING

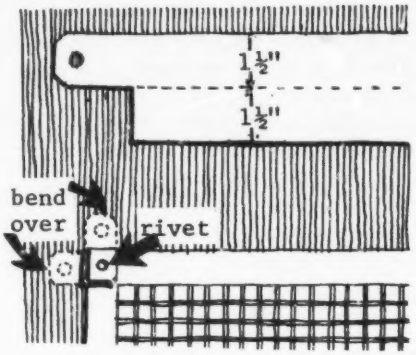
Ratproofing or vent stoppage consists of changing structural details to prevent entry of rodents into buildings. Openings as small as a half inch will admit young rats. Where only Norway rats are encountered, such openings as ground floor windows, sidewalk gratings, basement vents, utility pipe openings, and foundation walls are normally ratproofed; but where roof rats are found, ratproofing must also include wires, vertical pipes, and openings to upper floors and roofs. Where only Norway rats are encountered, the stoppage work, in order to be economically feasible, is confined to the more likely points of entry and not to every possible entrance.

DEVICES

1. The cuff and channel for wooden doors to side and back entrances prevent rats from gnawing under or around the doors. The front doors of most establishments are less exposed to rats and are generally protected with a kick plate. Wooden door jambs can be flashed with sheet metal to protect them from rat gnawing. Because open doors provide ready entry for rodents, both screen doors and wooden doors to food-handling establishments should be equipped with reliable self-closing devices.
2. Vents and windows can be made secure against rat entry by screening them with heavy wire mesh, preferably in a sheet-metal frame. If desired, fly screening can be incorporated into the frame also. Wooden surfaces exposed to gnawing must be covered by the frame.
3. Metal guards of suitable construction should be placed around or over wires and pipes to prevent rats from using them to gain entrance into a building.

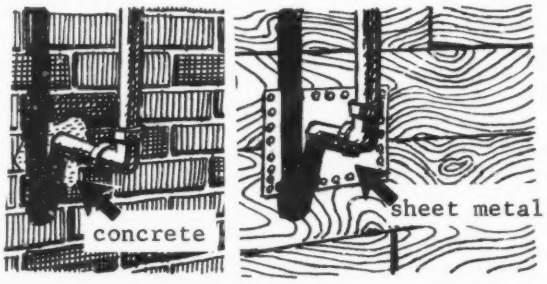


4. Openings around pipes or conduits should either be covered with sheet metal patches or filled with concrete or brick and mortar.
5. The use of concrete for basement floors and for foundations not only prevents rat entry but also increases the value of the property.
6. Floor drains, transoms, letter drops, and fan openings must receive stoppage consideration.



MATERIALS

1. 17-gauge, 2″ x 2″ (½-inch mesh) galvanized hardware cloth for screening against rats; 19-gauge, 4″ x 4″ (¼-inch mesh) for mice.
2. 18-gauge galvanized expanded metal for screening where exposure to damage is greater than normal.
3. 24- to 26-gauge galvanized sheet metal.
4. ⅛-inch brass or aluminum for kick plates.
5. Concrete, brick and mortar, glass, tile, and other building materials.



OTHER CONSIDERATIONS

As an adjunct to vent stoppage, buildings should be planned or modified to avoid dead spaces such as double walls, double floors, and enclosed areas under stairways.

Rubbish piles or other materials stacked against buildings should be removed. They provide the means by which rats and mice can bypass otherwise effective stoppage measures.

After buildings have been completely ratproofed, measures should be taken to eradicate the rodents that have been trapped within.

Inspections should be made at regular intervals to make sure that rats have not been reintroduced in incoming shipments and that the ratproofing work remains intact.

As a general guide in planning prevention measures, it will be assumed that *rats can do the following:*

1. Gain entrance through openings larger than ½-inch square.
2. Climb both horizontal and vertical wires.
3. Climb the inside of vertical pipes 1½ to 4 inches in diameter.
4. Climb the outside of vertical pipes and conduits with diameters up to 3 inches.
5. Climb the outside of vertical pipes and conduits of any size if within 3 inches of a wall.
6. Crawl horizontally on any type of pipe or conduit.
7. Jump vertically as much as 36 inches from a flat surface.
8. Jump horizontally 48 inches if on a flat surface.
9. Jump horizontally at least 8 feet from an elevation 15 feet above the finish point.
10. Reach about 18 inches horizontally or vertically.
11. Drop 50 feet without being killed.

NEW CONSTRUCTION

All new buildings should be so designed that they are ratproof. Building codes of communities should be revised, if necessary, to require that new construction be ratproof. Codes should also specify that modifications and repairs be made to existing buildings to render them ratproof.

ORGANIZATION OF COMMUNITY RAT-CONTROL PROGRAMS

In any community, careful planning must precede inauguration of a rodent-control program. As a basis for planning, a survey must be made to determine the degree and extent of infestation and to pinpoint problem areas, which in essence determines the type and size of program required. Survey results must be concisely summarized in a form suitable for presentation to local officials. This might be as a brief report supported by attractive and meaningful maps and graphs, and by 2" x 2" color slides and any other essential materials or documents that summarize and illustrate the problem and emphasize the need for a rodent-control program.

Based on the survey results, tentative estimates of space, material, and personnel requirements can then be made. The proposed role of private pest-control firms should be given, along with other proposed plans for the program. When local officials have approved and budgeted the rodent-control program, complete details of plans, facilities, and operations can then be developed and implemented. After the program is operational, additional surveys are made periodically to measure progress. Rat-survey methods are described in detail in the publication "Urban Rat Surveys."

ORGANIZATIONAL STRUCTURE

A workable organizational structure for rodent control in a community develops somewhat as follows:

1. The health department or other local agency employs staff to control rats in blighted residential areas, in sewers, and in public buildings on a permanent basis. Some cities contract this work out to private firms.
2. Local health agencies or departments of public works provide community-wide inspection and enforcement services. In many communities these services now are inadequate or non-existent, particularly in blighted areas, because of a shortage of funds, equipment, and personnel.
3. Private pest-control firms contract to control rats in private business establishments and in residences.
4. State and Federal health agencies offer limited consultation, training, and research in rodent control.

INFORMATION AND EDUCATION PROGRAM

The major element needed for a successful, long-lasting rodent-control project in a community is a strong, continuous educational program in environmental sanitation. It is essential that refuse (garbage and rubbish) handling facilities be improved, particularly in all blighted areas of the community, which invariably are the areas most heavily infested with rats. Proper storage of food and of refuse must be achieved neighborhood-by-neighborhood, block-by-block, residence-by-residence. Joint action of all concerned is essential.

Before refuse storage can be satisfactory, the local government MUST provide adequate refuse collection service (twice weekly to residences and daily to businesses is recommended). If refuse collection is not frequent and regular, householders cannot be expected to store refuse properly. Ordinances and timely enforcement are needed for those who refuse to obey regulations. Carelessness and indifference of any of the people are formidable foes to a successful rodent-control program, particularly in blighted areas. These attitudes must be fought with a continuous educational effort and with consistent, fair, resolute law-enforcement activity on a continuing basis.

Each year, the essentials of rodent control should be taught in the schools to all students of a receptive age group. Educational and promotional programs should be presented to community organizations such as Chambers of Commerce, Lions Clubs, Garden Clubs, and Rotary Clubs, and these groups should be invited to sponsor community projects to promote improvements.

For a rat-control program to be successful, educational and promotional work must reach the neighborhood or block levels. Oftentimes neighborhood garden or improvement clubs will assume leadership. In blighted areas, where the problem is greatest, resident block leaders must be found to spearhead needed improvements in their blocks on a continuous basis. In the neighborhood effort, Boy Scouts, Girl Scouts, and other youth groups are often of great help. Needless to say, the cooperation of all businesses, and particularly those handling food, is vital to the success of a rat-control program.

Stimulating neighborhood meetings must be held periodically to gain and to maintain neighborhood and block enthusiasm and support. New ideas or "gimmicks" must occasionally be incorporated into motivational efforts in order to sustain citizen interest.

Publicity through mass media (newspapers, radio, television, exhibits, leaflets, etc.) is helpful, particularly in the middle and high socioeconomic areas. However, these media often do not reach the majority of the householders in blighted areas where the need is greatest. There, personal contact, usually door to door, is required.

SUMMARY

Rats are filthy and destructive. They are widely feared and despised, and they spread disease and cause great economic losses.

Control of rats requires: (a) environmental sanitation to eliminate their food and harborage, (b) effective ratproofing, and (c) efficient killing programs. These control measures must become a way of life in the community if rat populations are to be kept low or eliminated.

Controlling rat populations, not individual rats, is the key to a successful rodent-control program in a community.

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